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RILEY RIDGE
NATURAL GAS PROJECT
AIR RESOURCES TECHNICAL REPORT

MAY 1983

Prepared by:
ENVIRONMENTAL RESEARCH
AND TECHNOLOGY, INC. for

DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT
DEPARTMENT OF AGRICULTURE
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AIR RESOURCES TECHNICAL REPORT
FOR THE RILEY RIDGE
ENVIRONMENTAL IMPACT STATEMENT

May 1983

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CLIMATOLOGICAL AND METEOROLOGICAL CHARACTERISTICS

The Riley Ridge Project area is located in the northern portion of the Sublette Air Basin in southwestern Wyoming. Refer to Map 1-1 (map pocket) which depicts major terrain in the study area. The air quality study area is bounded by the Wyoming-Utah border to the south, the Wyoming Range and Bear River Divide to the west, and the Wind River Range and the Great Divide Basin to the north through east. Synoptic wind flow in the area is predominantly from the west and southwest, however, these general wind patterns may be modified by the blocking effects of the mountains. In general, atmospheric dispersion of area pollutants is quite good because of the prevailing high wind speeds. During the day atmospheric dispersion is enhanced by strong surface heating providing for surface based instability. At night, however, surface drainage flows and stable atmospheric conditions may reduce dispersive capacity.

Much of the time modified Pacific air covers the state; cold air masses from Canada are less likely, and warm, moist air masses from the Gulf of Mexico are least likely to occur. Synoptic scale precipitation most often occurs with a low pressure center near the southern portion of Wyoming. This condition results in warm, moist, Pacific air aloft and cooler air near the surface. Frequent low pressure systems, originating from the Alberta area of Canada, tend to move southeasterly over the northern plains states, often causing strong, gusty winds over the area but little precipitation. Precipitation amounts vary considerably from one location to another. The period of maximum precipitation for most of the area is the late spring season. During the summer months, showers and thunderstorms are quite frequent, but generally light. Occasionally, heavy rains associated with thunderstorms occur locally within the area.

Because of its 6,000 to 8,000-foot elevation, the climate of the Sublette Air Basin is relatively cool, but with large seasonal and diurnal temperature changes. Summer nights are often cool, even though daytime maximum temperatures may reach 90°F. During the winter, cold frontal passages may give rise to rapid and frequent changes between warm and cold temperatures. Although temperatures are generally cooler in the mountains than the valleys, it is not unusual for the Green River Valley to be colder than the surrounding mountains. This results from the sheltering effect of the mountains and cold air drainage at night.

The following subsections describe in more detail the various meteorological characteristics pertinent to the Riley Ridge EIS.

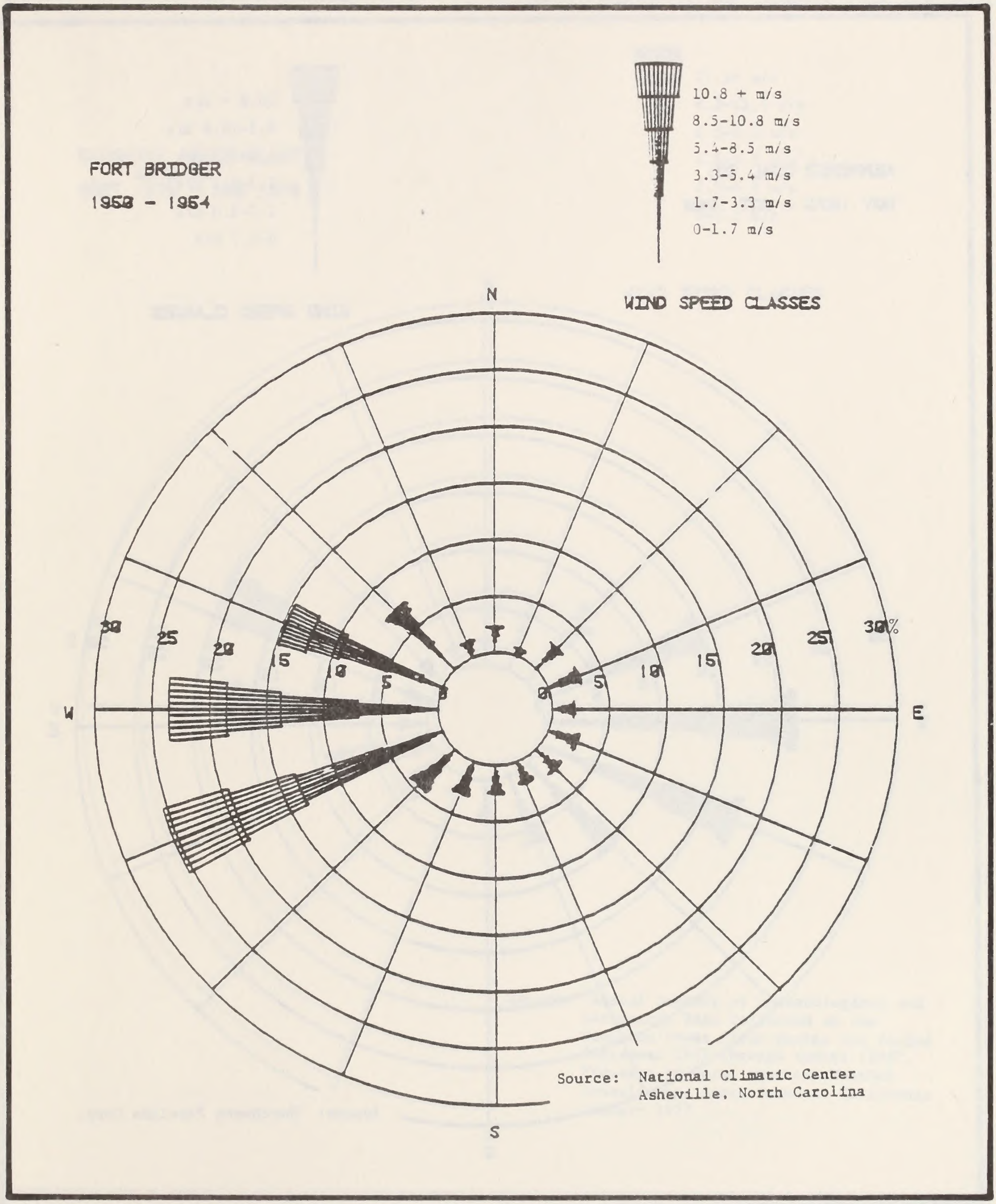
WINDS

Wind speed and direction information is critical in estimating atmospheric transport and dispersion. Ideally, meteorological data collected at the project sites should be used to enhance the accuracy of the transport and dispersion estimates. The companies are collecting this information in preparation for the PSD permit applications which should occur in mid to late 1983. Although meteorological monitoring programs are now underway at the various proposed plant sites, a full year of hourly meteorological data in the immediate Riley Ridge Project area was not available for EIS analysis. In the absence of these data, other meteorological data sets generally available in the region have been reviewed for dispersion modeling use and representativeness. These data sources include: the Fort Bridger Civil Aeronautics Administration's 60-foot tower; FMC Corporation's Green River site; Utah Power and Light Company's Naughton Power Plant sites; Amoco's Whitney Canyon site, the Kemmerer Coal 10-meter tower, and the National Weather Service's Rock Springs station. (The National Weather Service Automatic Meteorological Observing Station (AMOS) at the Big Piney airport could be extremely useful in estimating atmospheric transport and dispersion because of its proximity to the project sites, but unfortunately the Big Piney data are not archived.) Although these off-site data are not preferable to on-site data, they are the best data presently available for making this assessment. The locations of these meteorological monitoring stations are shown in Map 1-1 (map pocket).

A summary of the available surface wind speed and wind direction data for five sites is shown in Figures 1-1 through 1-5 (FMC-Green River data are not shown because the available data were not stratified by wind speed). These figures provide wind roses indicating the frequency of occurrence of wind speed and direction for the appropriate period of record for each site. Each of the wind roses shows that winds with strong westerly components are most frequent. In addition, all data sources demonstrate that the highest wind speeds are associated with westerly winds.

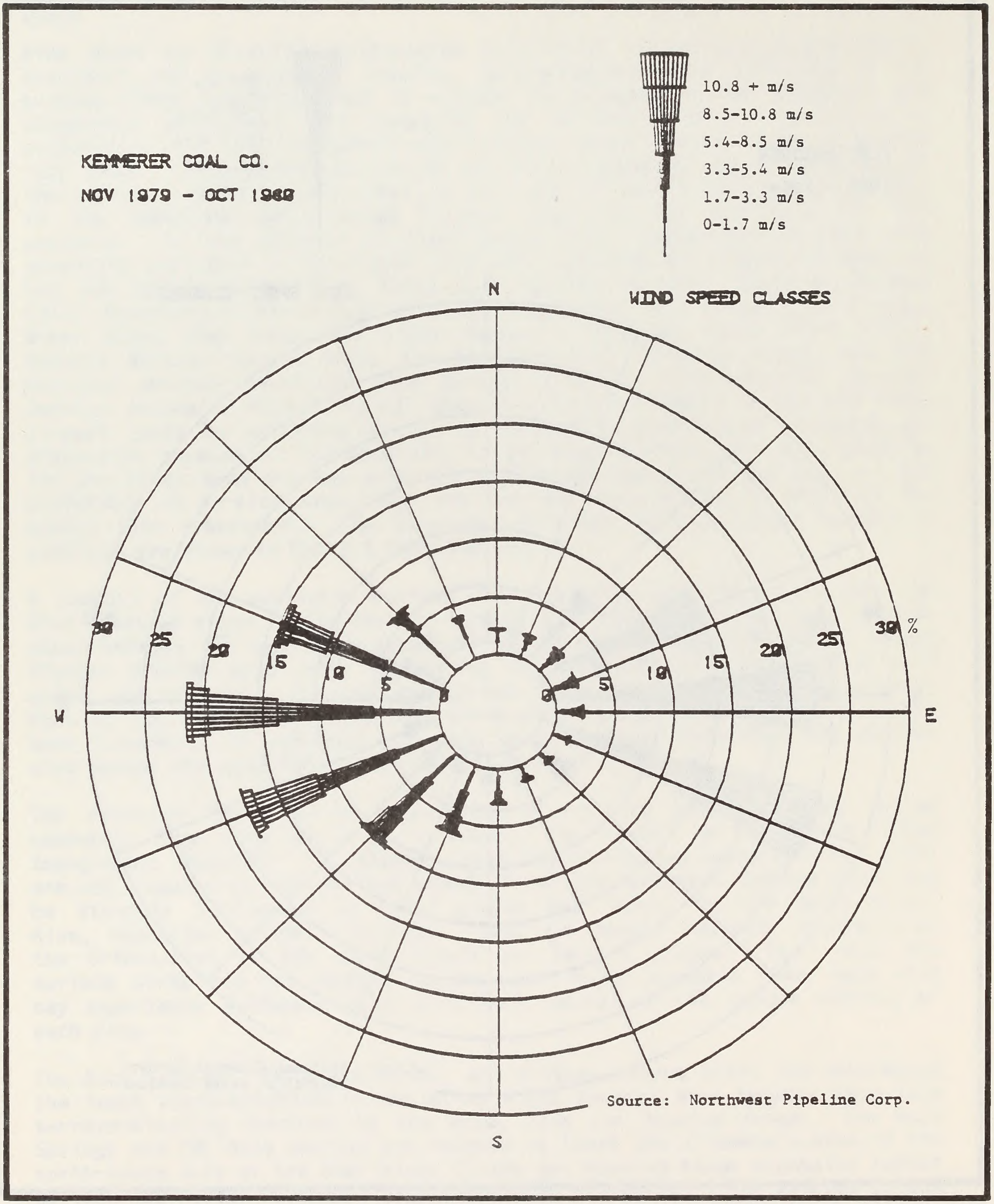
The relative frequency of occurrence of calm or easterly winds varies somewhat from site to site, probably the result of different local topographic features. For example, when the prevailing westerly winds aloft are not coupled to the surface winds, light and variable daytime winds may be strongly influenced by local slopes and nearby terrain orientation. Also, nighttime katabatic/drainage flows are almost entirely dependent on the orientation of the local rivers and terrain slopes. Thus, when the surface winds are not coupled to the upper level synoptic flow, each site may experience different wind directions caused by the unique setting of each site.

The Rock Springs, FMC Green River, and Whitney Canyon sites are considered the least representative of the Riley Ridge Project area because they lack terrain-blocking features to the west, like the Wyoming Range. The Rock Springs and FMC data sources are located at least 100 kilometers east of the north-south axis of the Bear River Divide and Wyoming Range mountains (which defines the western boundary of the Sublette Air Basin). The Whitney Canyon site is located near the head of Whitney Canyon, on the Bear River Divide. Because local terrain features are critical in characterizing representative wind flow patterns, these three sites are probably less representative than the Naughton Power Plant, Kemmerer Coal, and Fort Bridger sites.



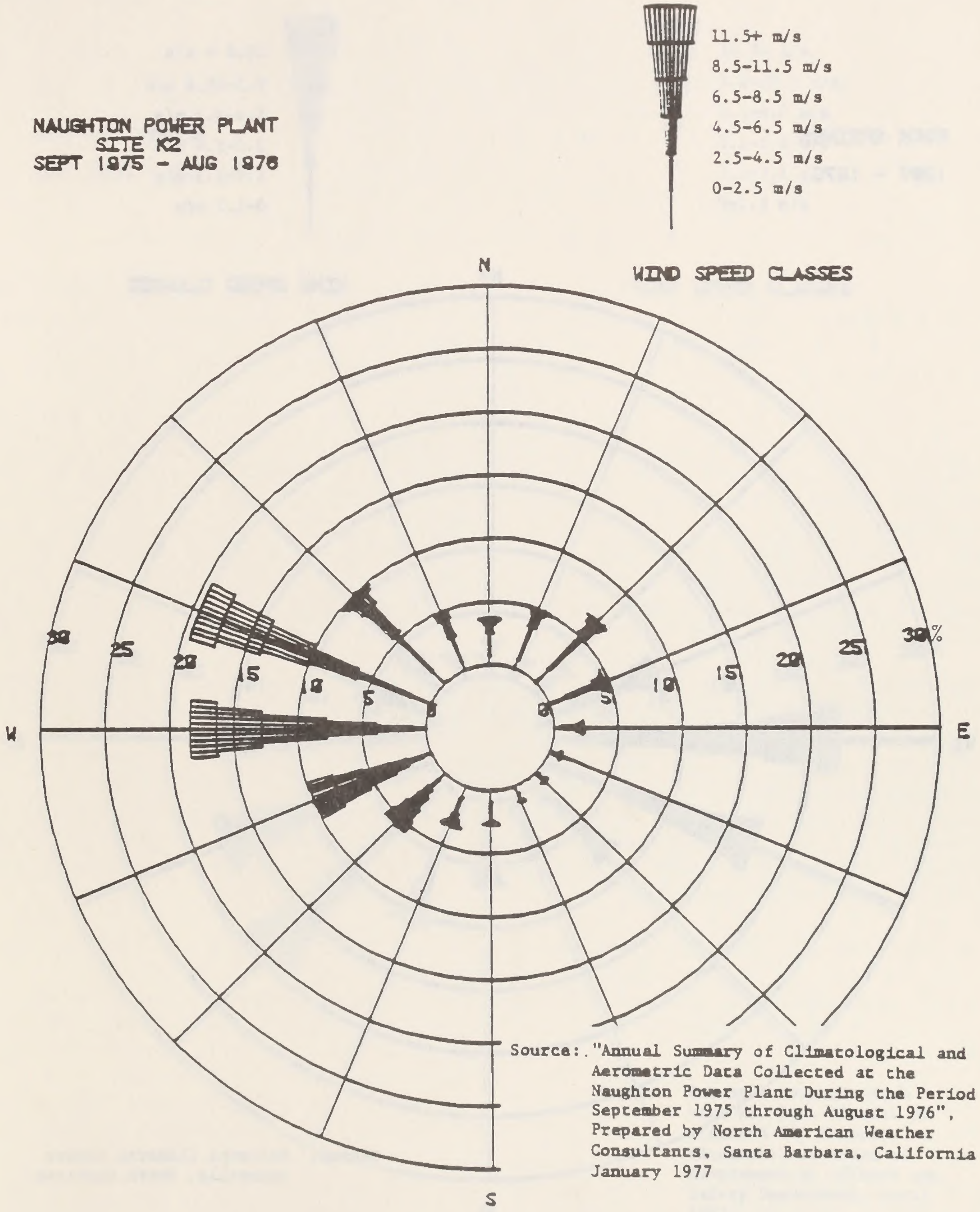
Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-1 FORT BRIDGER WIND ROSE (1950-1954)



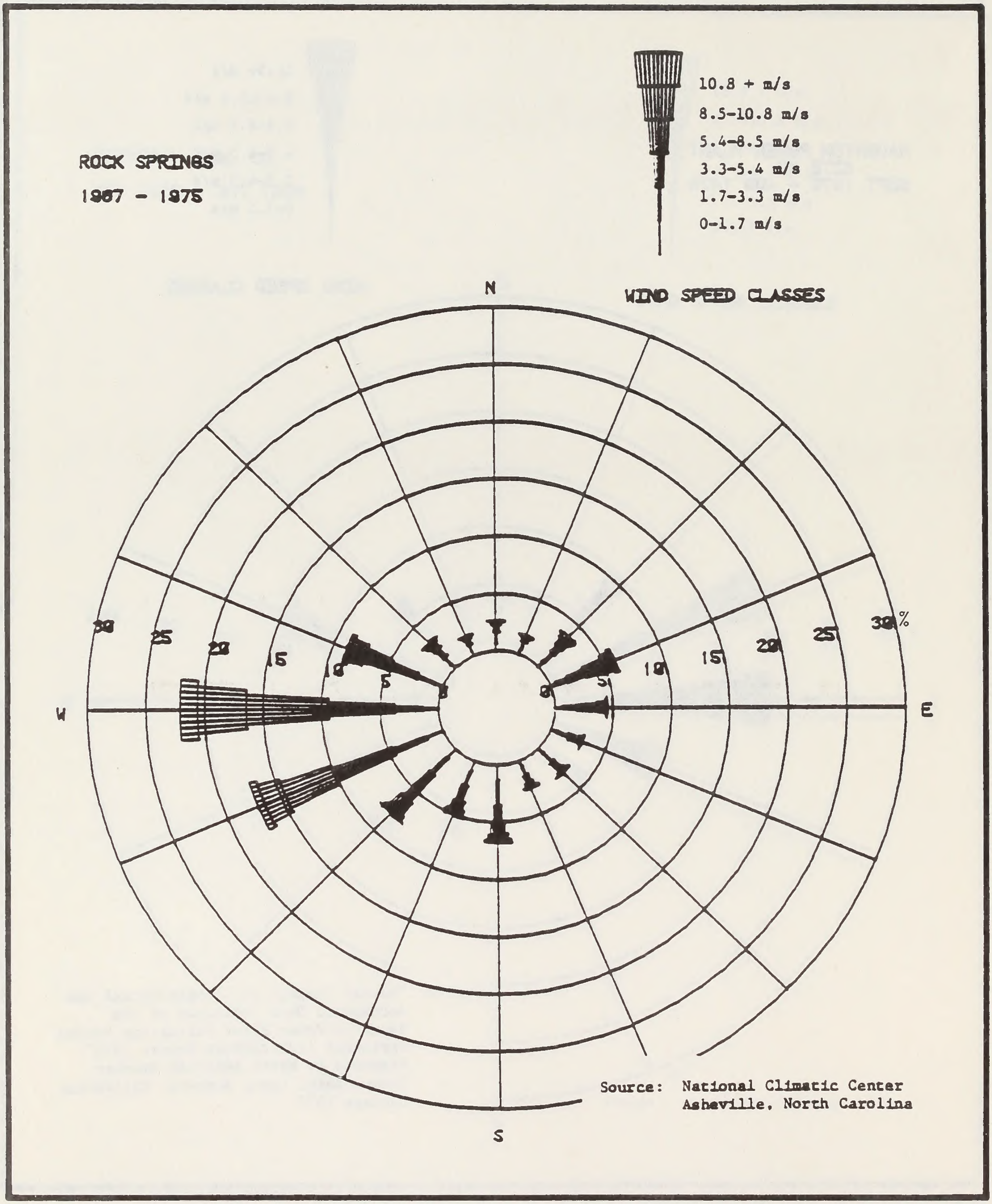
Source: Northwest Pipeline Corp.

FIGURE 1-2 KEMMERER COAL CO. WIND ROSE (NOV 1979-OCT 1980)



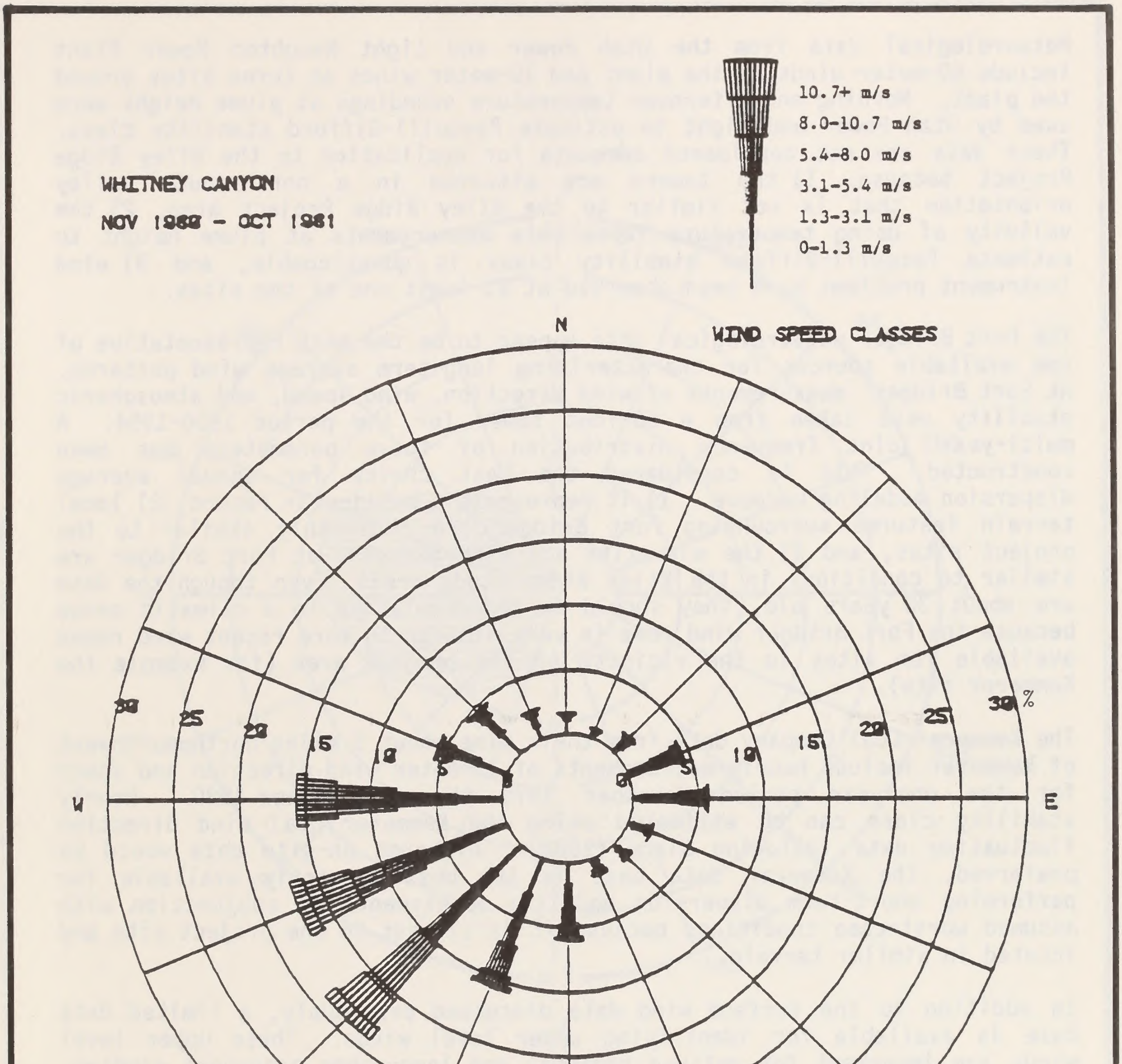
Source: "Annual Summary of Climatological and Aerometric Data Collected at the Naughton Power Plant During the Period September 1975 through August 1976", Prepared by North American Weather Consultants, Santa Barbara, California January 1977

FIGURE 1-3 NAUGHTON POWER PLANT WIND ROSE (SITE K2—SEPT 1975-AUG 1976)



Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-4 ROCK SPRINGS WIND ROSE (1967-1975)



Source: Personal communication with Mr. D.N. Blewitt of Standard Oil Company (Indiana), Division of Environmental Affairs and Safety Department, April 1982

FIGURE 1-5 WHITNEY CANYON WIND ROSE (NOV 1980-OCT 1981)

Meteorological data from the Utah Power and Light Naughton Power Plant include 60-meter winds at the plant and 10-meter winds at three sites around the plant. Morning and afternoon temperature soundings at plume height were used by Utah Power and Light to estimate Pasquill-Gifford stability class. These data are not considered adequate for application to the Riley Ridge Project because: 1) the towers are situated in a north-south valley orientation that is not similar to the Riley Ridge Project area, 2) the validity of using temperature lapse rate measurements at plume height to estimate Pasquill-Gifford stability class is questionable, and 3) wind instrument problems have been observed at at least one of the sites.

The Fort Bridger meteorological data appear to be the most representative of the available sources for characterizing long-term average wind patterns. At Fort Bridger, measurements of wind direction, wind speed, and atmospheric stability were taken from a 60-foot tower for the period 1950-1954. A multi-year joint frequency distribution of these parameters has been constructed. This is considered the best choice for annual average dispersion modeling because: 1) it represents a multi-year record, 2) local terrain features surrounding Fort Bridger are reasonably similar to the project sites, and 3) the elevation and site exposure at Fort Bridger are similar to conditions in the Riley Ridge study area. Even though the data are about 30 years old, they should be representative in a climatic sense because the Fort Bridger wind rose is very similar to more recent wind roses available for sites in the vicinity of the project area (for example the Kemmerer site).

The Kemmerer Coal Company data from their mine about 5 miles north-northwest of Kemmerer include hourly measurements of 10-meter wind direction and speed for the one-year period November 1979 through October 1980. Hourly stability class can be estimated using the Kemmerer Coal wind direction fluctuation data following Slade (1968). Although on-site data would be preferred, the Kemmerer data base is the best presently available for performing short-term dispersion modeling assessments in conjunction with assumed worst-case conditions because it is closest to the project site and located in similar terrain.

In addition to the surface wind data discussed previously, a limited data base is available for identifying upper level winds. These upper level winds are important for refined regional and long-range transport studies. Sources of upper level wind data include the Naughton Power Plant and the NWS upper air station at Lander, Wyoming. The Naughton Plant data are based on 362 pilot balloon releases during 1975 and 1976. The Lander data are based on routine (twice daily) radiosondes during 1974 through 1978. The Naughton data show that upper level morning winds are predominantly from the west through northwest, and change very little up to 1,500 meters above ground. The afternoon winds are typically more westerly at all altitudes. Average wind speeds range from 5 to 7 meters per second near the surface to 9 to 11 meters per second at 1,500 meters above ground.

The annual wind rose (frequency of wind direction only) for the 500-millibar pressure surface at Lander is shown in Figure 1-6. The 500-millibar surface is several miles above the local terrain features. Essentially all observed winds have a major westerly component.

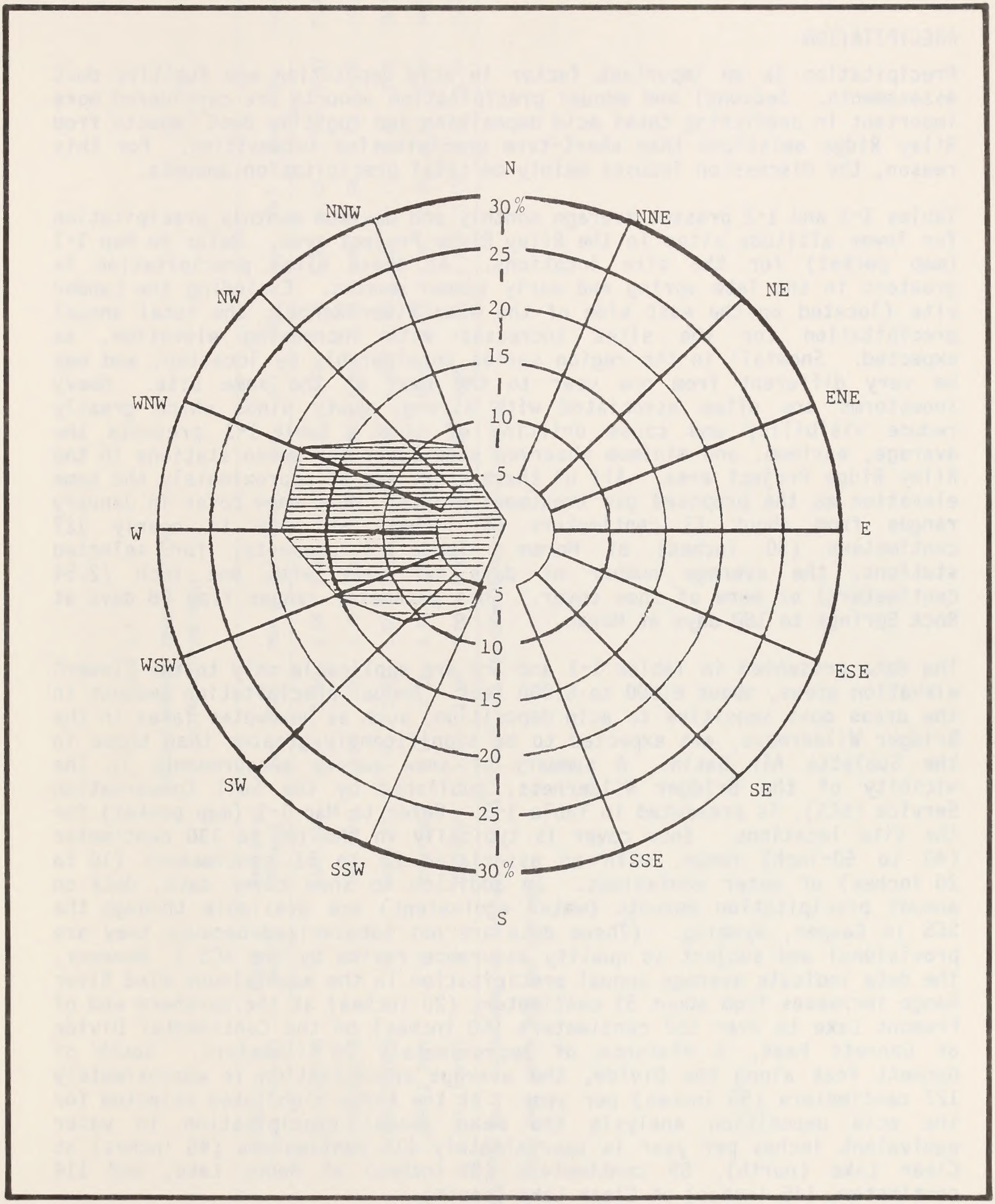


FIGURE 1-6 ANNUAL WIND DIRECTION FREQUENCY DISTRIBUTION FOR THE 500 MILLIBAR LEVEL FOR LANDER (1974-1978)

PRECIPITATION

Precipitation is an important factor in acid deposition and fugitive dust assessments. Seasonal and annual precipitation amounts are considered more important in predicting total acid deposition and fugitive dust impacts from Riley Ridge emissions than short-term precipitation intensities. For this reason, the discussion focuses mainly on total precipitation amounts.

Tables 1-1 and 1-2 present average monthly and maximum monthly precipitation for lower altitude sites in the Riley Ridge Project area. Refer to Map 1-1 (map pocket) for the site locations. At these sites precipitation is greatest in the late spring and early summer months. Excluding the Lander site (located on the east side of the Wind River Range), the total annual precipitation for the sites increases with increasing elevation, as expected. Snowfall in the region varies considerably by location, and may be very different from one year to the next at the same site. Heavy snowstorms are often associated with strong, gusty winds which greatly reduce visibility and cause drifting of snow. Table 1-3 presents the average, maximum, and minimum observed snow cover for seven stations in the Riley Ridge Project area. All of these sites are at approximately the same elevation as the proposed gas treatment plants. Mean snow cover in January ranges from about 13 centimeters (5 inches) at Sage to nearly 127 centimeters (50 inches) at Moran. Table 1-4 presents, for selected stations, the average number of days per year with one inch (2.54 centimeters) or more of snow cover. This parameter ranges from 68 days at Rock Springs to 180 days at Moran.

The data presented in Tables 1-1 and 1-2 are applicable only to the "lower" elevation areas, about 6,000 to 8,000 feet. Annual precipitation amounts in the areas most sensitive to acid deposition, such as headwater lakes in the Bridger Wilderness, are expected to be significantly greater than those in the Sublette Air Basin. A summary of snow survey measurements in the vicinity of the Bridger Wilderness, published by the Soil Conservation Service (SCS), is presented in Table 1-5. Refer to Map 1-1 (map pocket) for the site locations. Snow cover is typically in the 100 to 130 centimeter (40 to 50-inch) range, with an associated 25 to 51 centimeters (10 to 20 inches) of water equivalent. In addition to snow cover data, data on annual precipitation amounts (water equivalent) are available through the SCS in Casper, Wyoming. (These data are not tabularized because they are provisional and subject to quality assurance review by the SCS.) However, the data indicate average annual precipitation in the mountainous Wind River Range increases from about 51 centimeters (20 inches) at the northern end of Fremont Lake to over 152 centimeters (60 inches) on the Continental Divide at Gannett Peak, a distance of approximately 20 kilometers. South of Gannett Peak along the Divide, the average precipitation is approximately 127 centimeters (50 inches) per year. At the three high lakes selected for the acid deposition analysis the mean annual precipitation in water equivalent inches per year is approximately 114 centimeters (45 inches) at Clear Lake (north), 89 centimeters (35 inches) at Hobbs Lake, and 114 centimeters (45 inches) at Clear Lake (south).

Drought and flooding occur with unusually low or high amounts of precipitation. Fairly common in the area, droughts were quite widespread throughout the state in 1952, 1954, 1956, and 1966. Flooding typically

TABLE 1-1

MAXIMUM MONTHLY PRECIPITATION

(TOTAL CENTIMETERS)

Station	Elevation in Feet (Meters)	Years of Record	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Big Piney	6,820 (2,079)	37	1941-1977	0.94	0.84	1.04	2.13	3.33	3.12	1.91	2.31	2.29	1.65	1.12	1.17	21.84
Kemmerer	6,958 (2,121)	37	1941-1977	1.68	1.55	1.70	1.83	3.12	0.36	1.30	2.08	1.85	1.88	1.80	1.80	24.21
Pinedale	7,175 (2,187)	37	1941-1977	1.85	1.50	1.60	2.34	3.99	4.06	1.96	2.59	2.39	2.13	1.80	2.31	28.52
South Pass City	7,840 (2,390)	37	1941-1977	3.18	2.13	3.10	3.99	3.76	4.32	1.55	2.13	2.36	2.79	2.77	2.79	34.87
Lander	5,557 (1,694)	37	1941-1977	1.22	1.68	3.00	5.99	6.58	4.90	1.55	1.07	2.67	3.15	2.21	1.14	35.15

Source: Environmental Data and Information Service, National Oceanic and Atmospheric Administration 1980.

[1] Total number of years over which data was averaged.

TABLE 1-2

MAXIMUM MONTHLY PRECIPITATION
(TOTAL CENTIMETERS)

Station	Elevation in Feet (Meters)	Years of Record	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Big Piney	6,820 (2,079)	37	1941-1977	3.18	2.82	3.71	5.92	8.84	7.52	4.24	7.49	6.22	7.09	3.15	3.45
Kemmerer	6,958 (2,121)	37	1941-1977	4.29	5.21	5.69	4.57	7.47	10.49	7.90	5.38	5.89	6.17	4.34	4.42
Pinedale	7,175 (2,187)	37	1941-1977	7.47	4.65	5.44	6.35	9.50	8.43	5.44	7.87	6.43	7.16	6.25	6.17
South Pass City	7,840 (2,390)	37	1941-1977	19.35	5.77	6.63	11.35	9.73	12.22	6.15	6.76	10.16	6.88	8.79	11.58
Lander	5,557 (1,694)	37	1941-1977	4.19	5.54	8.38	13.87	15.32	17.48	6.35	4.50	11.89	9.09	5.46	3.84

Source: Science Applications, Final Report: Baseline Climate and Air Quality for BLM Lands in Wyoming, July 1980.

TABLE 1-3

SNOW COVER IN THE RILEY RIDGE PROJECT AREA
(CENTIMETERS)

Station	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
Sage													
Mean	0.0	0.0	0.0	4.3	9.9	22.6	22.6	18.0	18.0	9.9	1.8	0.0	106.9
Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	0.0	0.0	0.0	0.0	46.5
Max.	0.0	0.0	0.0	35.6	40.6	61.0	52.1	41.9	56.6	31.8	27.9	T	191.3
Alta													
Mean	0.0	0.3	2.0	18.3	33.8	52.8	56.9	40.4	41.1	31.5	9.1	0.8	287.0
Min.	0.0	0.0	0.0	0.0	T	12.7	T	11.4	7.6	T	0.0	0.0	152.4
Max.	T	5.1	25.4	86.4	71.1	129.5	144.8	66.5	90.2	88.9	65.3	17.8	433.1
Jackson													
Mean	0.0	0.0	1.0	6.4	23.1	46.2	58.9	31.8	33.3	19.1	3.6	0.5	223.8
Min.	0.0	0.0	0.0	0.0	0.2	0.0	0.0	2.5	7.6	T	0.0	0.0	91.9
Max.	0.0	0.0	12.7	26.7	66.0	101.6	142.2	81.0	63.5	61.0	27.9	12.7	389.1
Moran													
Mean	0.0	0.0	5.1	15.0	59.9	107.7	123.4	81.8	74.7	35.6	6.6	1.3	511.0
Min.	0.0	0.0	0.0	0.0	2.5	22.9	20.3	36.8	20.3	10.2	0.0	0.0	308.6
Max.	T	T	50.8	64.8	109.2	201.9	236.2	172.2	176.5	78.2	27.9	16.5	693.4
Pinedale													
Mean	0.0	0.0	1.5	7.4	21.1	32.0	35.1	27.7	21.6	19.3	4.1	0.0	169.7
Min.	0.0	0.0	0.0	T	T	1.5	0.0	0.0	0.0	T	0.0	0.0	72.1
Max.	T	T	20.3	33.0	51.8	91.4	175.3	91.4	50.8	34.3	39.6	T	259.8
Green River													
Mean	0.0	0.0	1.3	6.4	11.2	11.2	12.7	10.7	12.2	8.6	2.5	0.0	76.7
Min.	0.0	0.0	0.0	0.0	T	0.0	2.5	0.0	1.3	0.0	0.0	0.0	43.2
Max.	0.0	0.0	27.9	45.7	31.8	31.8	49.5	50.3	43.9	36.3	25.4	0.0	158.2
Rock Springs													
Mean	0.0	0.0	2.3	9.1	12.4	15.0	14.2	15.0	17.5	15.7	4.3	0.3	105.9
Min.	0.0	0.0	0.0	0.0	T	T	2.5	T	1.5	T	0.0	0.0	51.3
Max.	T	T	56.9	47.8	36.6	49.0	34.3	43.2	50.3	40.4	29.2	2.3	160.8

Source: Science Applications, Final Report: Baseline Climate and Air Quality for BLM Lands in Wyoming, July 1980.

[1] T = Trace

TABLE 1-4

MEAN ANNUAL NUMBER OF DAYS WITH 1 INCH (2.54 CENTIMETERS) OR MORE OF SNOW COVER (PERIOD OF RECORD 1963-1977)

Station	Elevation in Feet (meters)	Number of Days
Afton	6,115 (1,864)	135
Alta	6,431 (1,960)	167
Kendall	7,665 (2,336)	175
Moran	6,740 (2,054)	180
Pinedale	7,175 (2,187)	136
Rock Springs	6,741 (2,055)	68

Source: Science Applications, Final Report: Baseline Climate and Air Quality for BLM Lands in Wyoming, July 1980.

TABLE 1-5

SNOW COVER AT REMOTE SITES NEAR THE BRIDGER WILDERNESS
[SNOW DEPTH (CENTIMETERS)/WATER EQUIVALENT (CENTIMETERS)]

	Feb 1	Mar 1	Apr 1	May 2	Site Elevation in Feet (Meters)	Site Location
Hobbs Park	88.9/23.4	104.1/29.2	127/36.8	142.2/45.0	10,000 (3,048)	42° 52', 109° 06'
Dinwoody	83.8/20.6	96.5/25.9	116.8/31.8	124.5/36.6	10,160 (3,097)	43° 16', 109° 28'
Little Warm	109.2/27.9	124.5/35.3	147.3/43.9	154.9/50.3	9,620 (2,932)	43° 30', 109° 45'
Larsen Creek	94.0/22.4	104.1/28.2	106.7/30.7	83.8/27.4	9,020 (2,749)	42° 36', 109° 05'
New Fork Lake[1]	88.9/21.8	99.1/26.9	104.1/30.7	78.7/28.4	8,340 (2,542)	43° 07', 109° 57'
Pocket Creek[1]	94.0/22.4	109.2/29.5	116.8/33.0	111.8/36.3	9,350 (2,850)	42° 42', 109° 25'
Elkhart Park[1]	101.6/24.4	116.8/31.5	129.5/38/1	119.4/39.9	9,400 (2,865)	43° 00', 109° 45'

Source: Summary of Snow Survey Measurements in Wyoming, Soil Conservation Service, 1979. Data based on the period 1949 through 1978

[1] Data based on the period 1961 through 1978

occurs when heavy spring rains combine with accelerated snow melt. During the period 1948-1970, three damaging floods in the Pinedale and Kemmerer areas were recorded. These events, causing slight damage, occurred in the early and late spring. Kemmerer also flooded during the spring of 1980 causing significant damage.

STABILITY AND MIXING HEIGHT

Atmospheric stability and mixing height are important parameters in air quality dispersion studies. Stability of the atmosphere is a direct measure of dispersive capability. Plumes tend to disperse rapidly in unstable conditions, and disperse very slowly in stable conditions. The stability can be estimated from the vertical temperature profile, solar insolation, and wind speed, or from the variance of the horizontal or vertical wind.

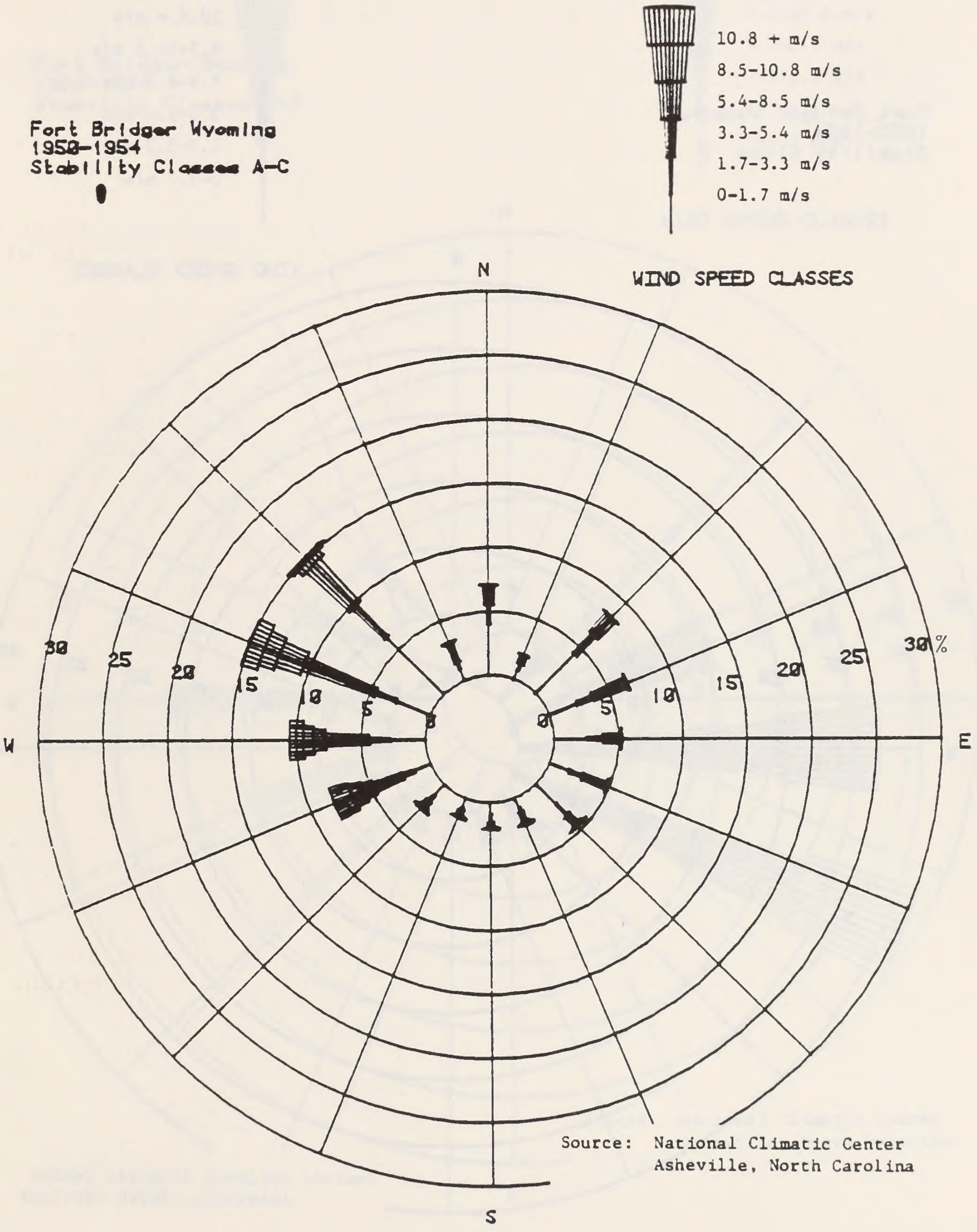
Figures 1-7 through 1-12 present long-term average wind roses by stability class for Fort Bridger and Rock Springs. The frequency of occurrence of wind speed and direction for each stability class is very helpful in characterizing atmospheric dispersion conditions. The stable wind roses show that moderate (7-10 knots) westerly winds are most frequent at Fort Bridger; lighter (4-6 knots) west-southwest winds are most frequent at Rock Springs. The Fort Bridger data indicate that overall, stable conditions occur 14 percent of the time, while at Rock Springs stable conditions occur nearly 30 percent of the time.

The neutral stability wind roses both show the predominance of west and west-southwesterly winds at moderate to strong speeds. Neutral conditions are found 68 and 57 percent of the time at Fort Bridger and Rock Springs, respectively. Unstable atmospheric stability is most frequently found with light west-northwesterly winds at Fort Bridger, and with light westerly winds at Rock Springs. Unstable conditions are found 18 percent of the time at Fort Bridger and 13 percent of the time at Rock Springs. Both of the unstable class wind roses show much more variability among wind directions than do either the neutral or stable class wind roses. In consideration of Fort Bridger's proximity to the Bear River Divide, as well as the sheltering of the Rock Springs site, the Fort Bridger data set is considered more representative of conditions at the proposed Riley Ridge Project sites.

The mixing height, a measure of the ground-based layer in the atmosphere through which vertical mixing can occur, is usually most important in assessing intermediate and long-range transport and dispersion. (Mixing height is usually defined by temperature lapse rate measurements.) Mixing heights in the project area range from 300 meters during winter mornings to 3,600 meters on summer afternoons. The mixing height rapidly changes during convection during the morning hours when solar radiation rapidly heats the air near the surface. Typically, the mixing height reaches a maximum in the late afternoon hours.

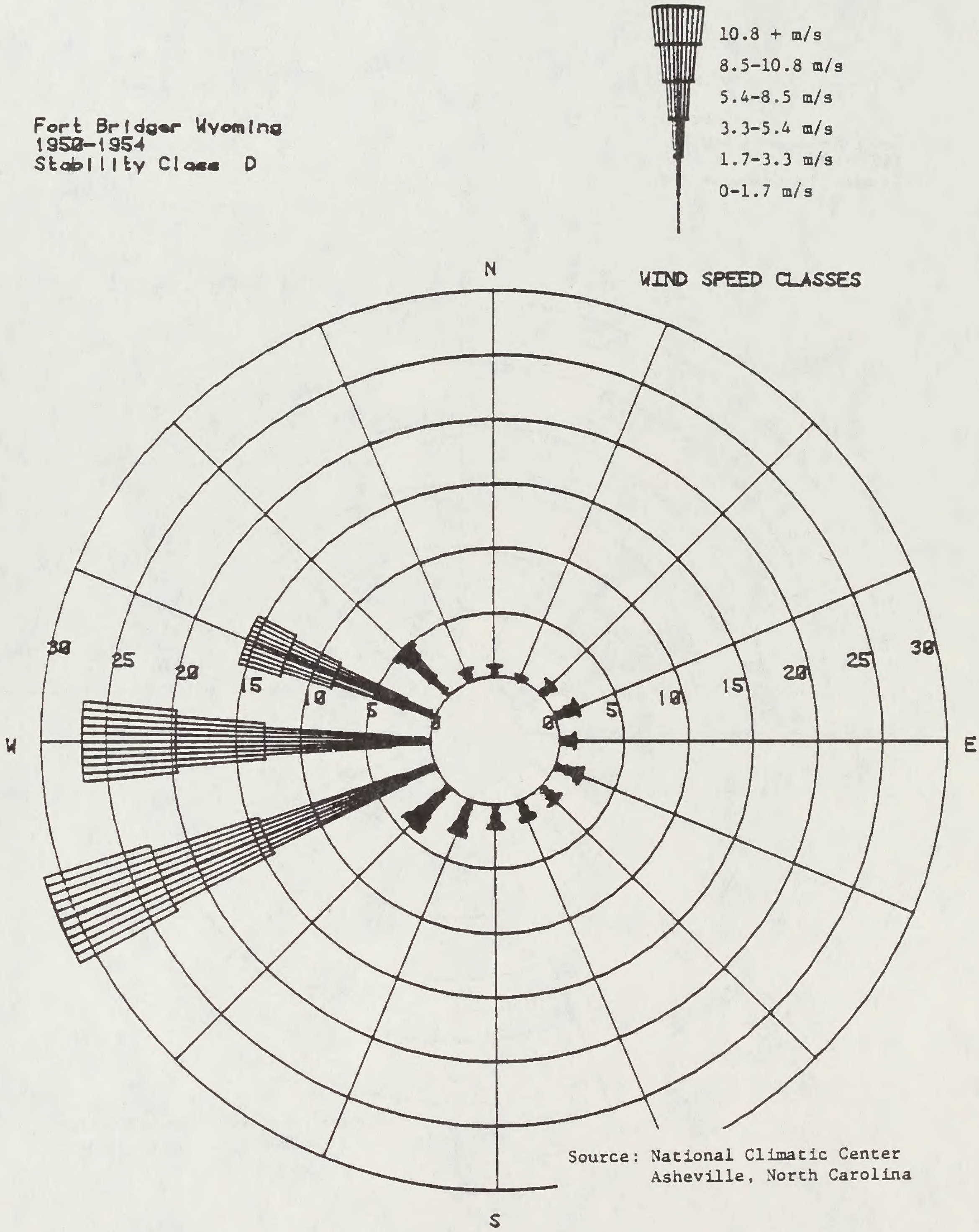
TEMPERATURE AND RELATIVE HUMIDITY

A wealth of temperature data exist in the Riley Ridge area. Figures 1-13 and 1-14 present mean and extreme temperature data for two sites in the Sublette Air Basin for an extended period of record. The Kemmerer data show slightly higher temperatures than those at Big Piney. The Big Piney data show that average temperatures are below freezing from November through



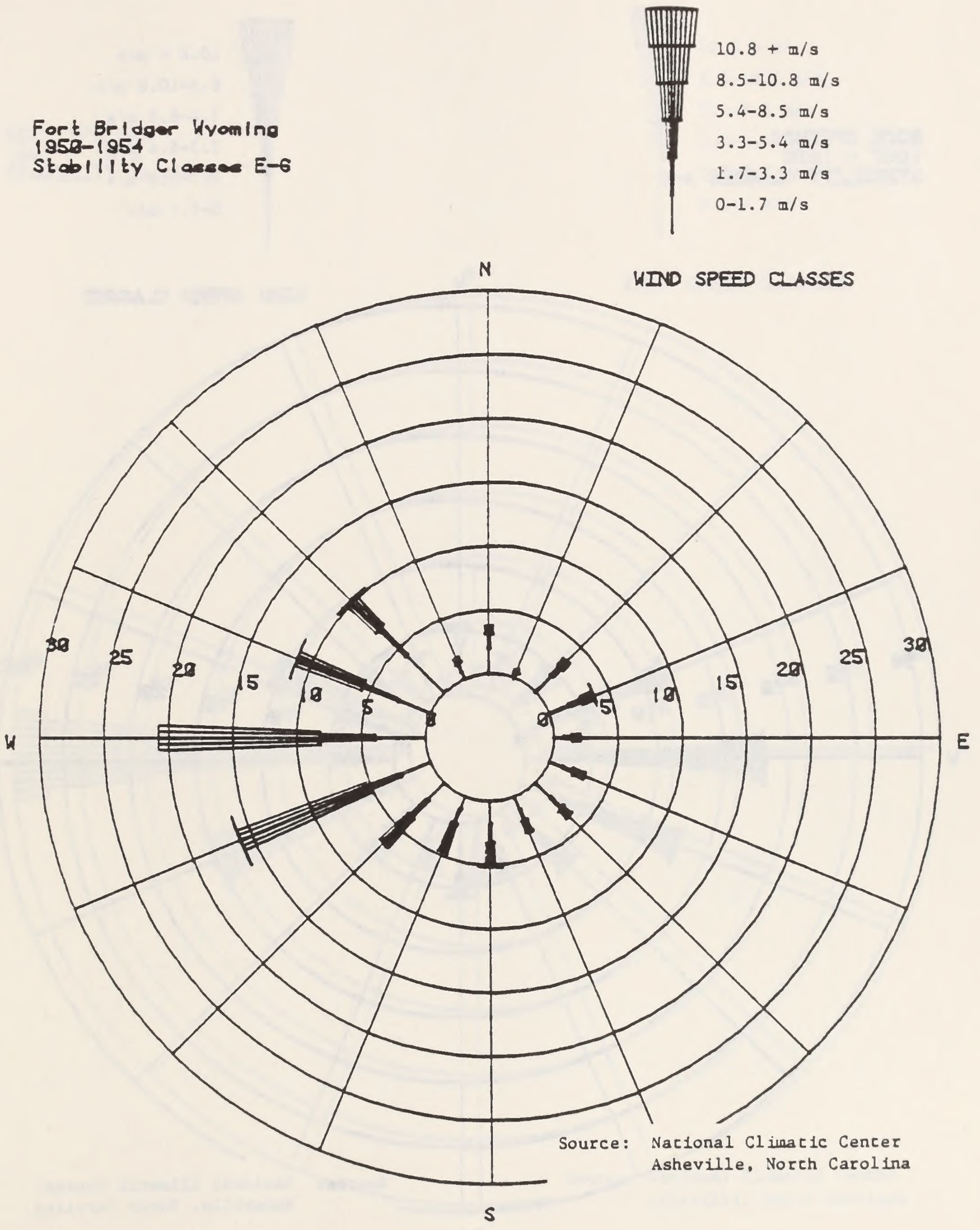
Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-7 FORT BRIDGER WYOMING WIND ROSE (1950-1954) STABILITY CLASSES A-C



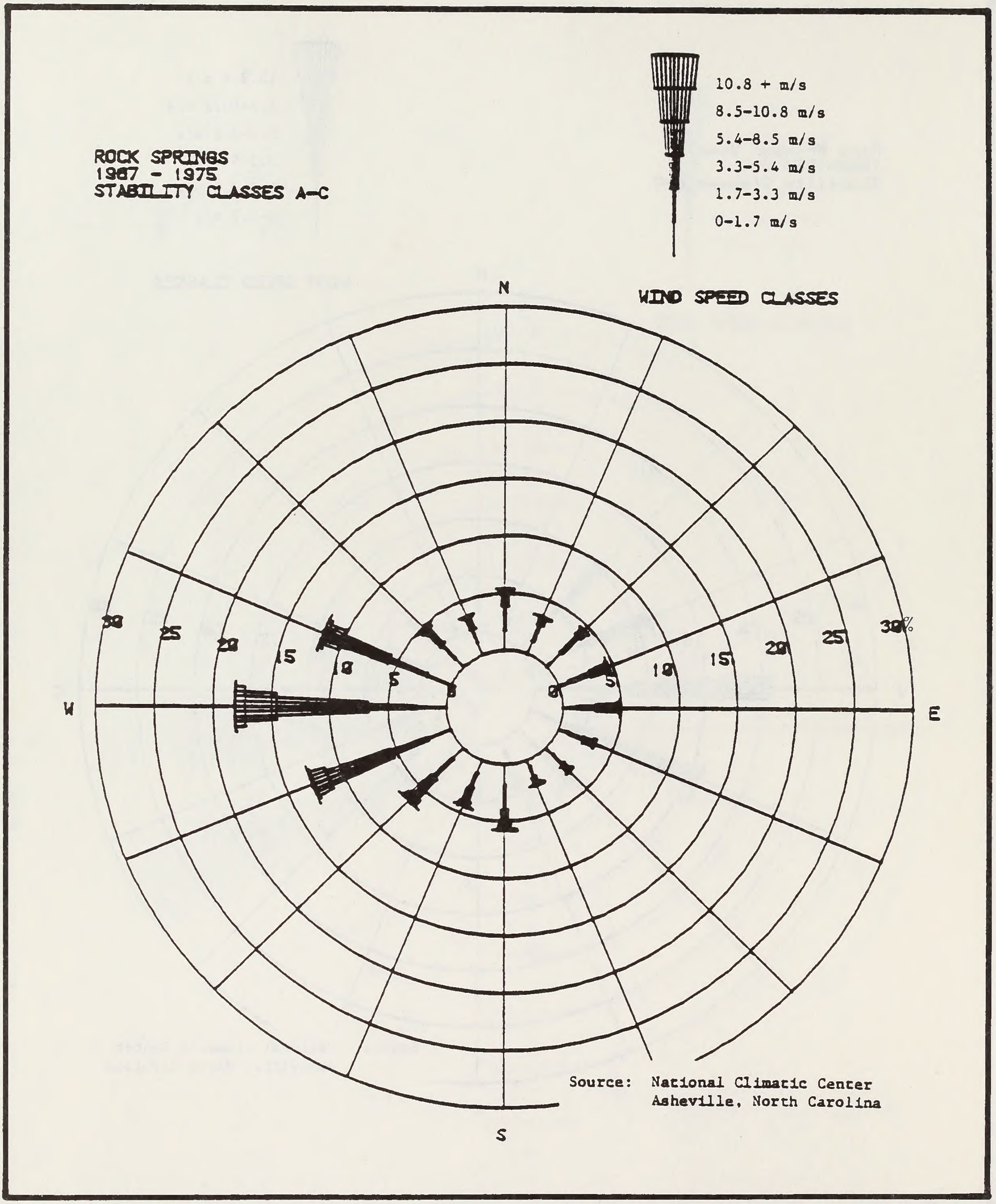
Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-8 FORT BRIDGER WYOMING WIND ROSE (1950-1954) STABILITY CLASS D



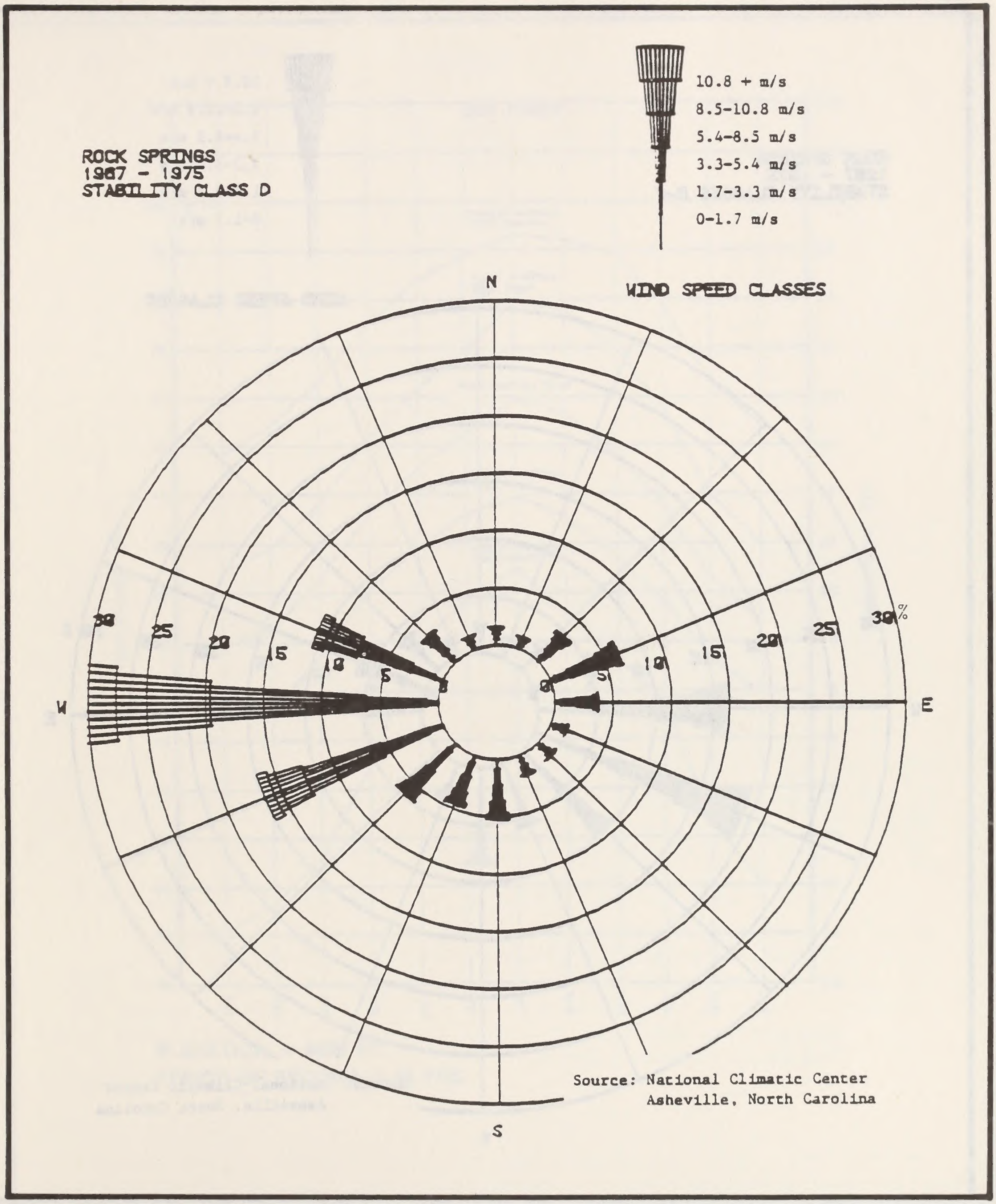
Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-9 FORT BRIDGER WYOMING WIND ROSE (1950-1954) STABILITY CLASSES E-G



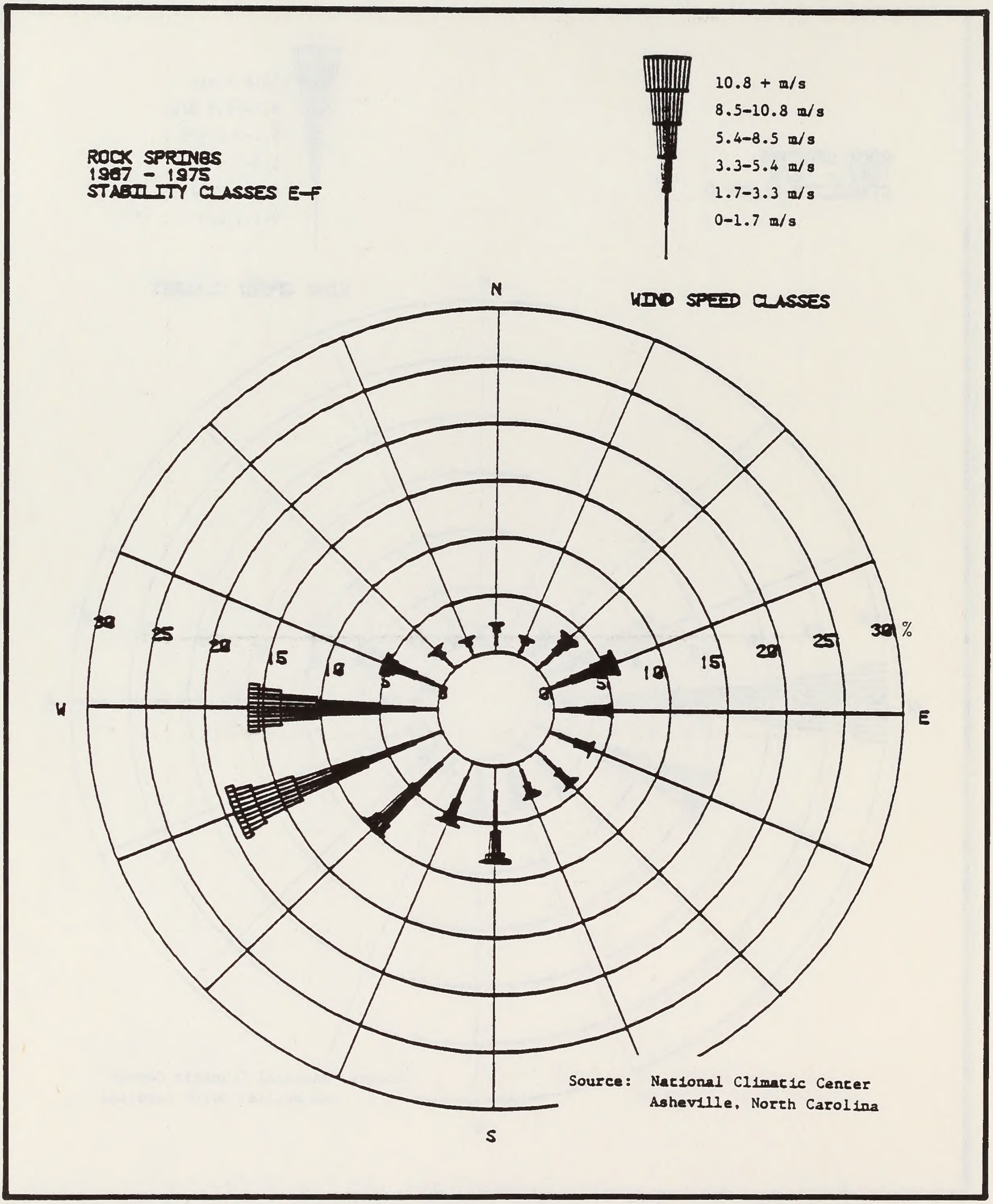
Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-10 ROCK SPRINGS WIND ROSE (1967-1975) STABILITY CLASSES A-C



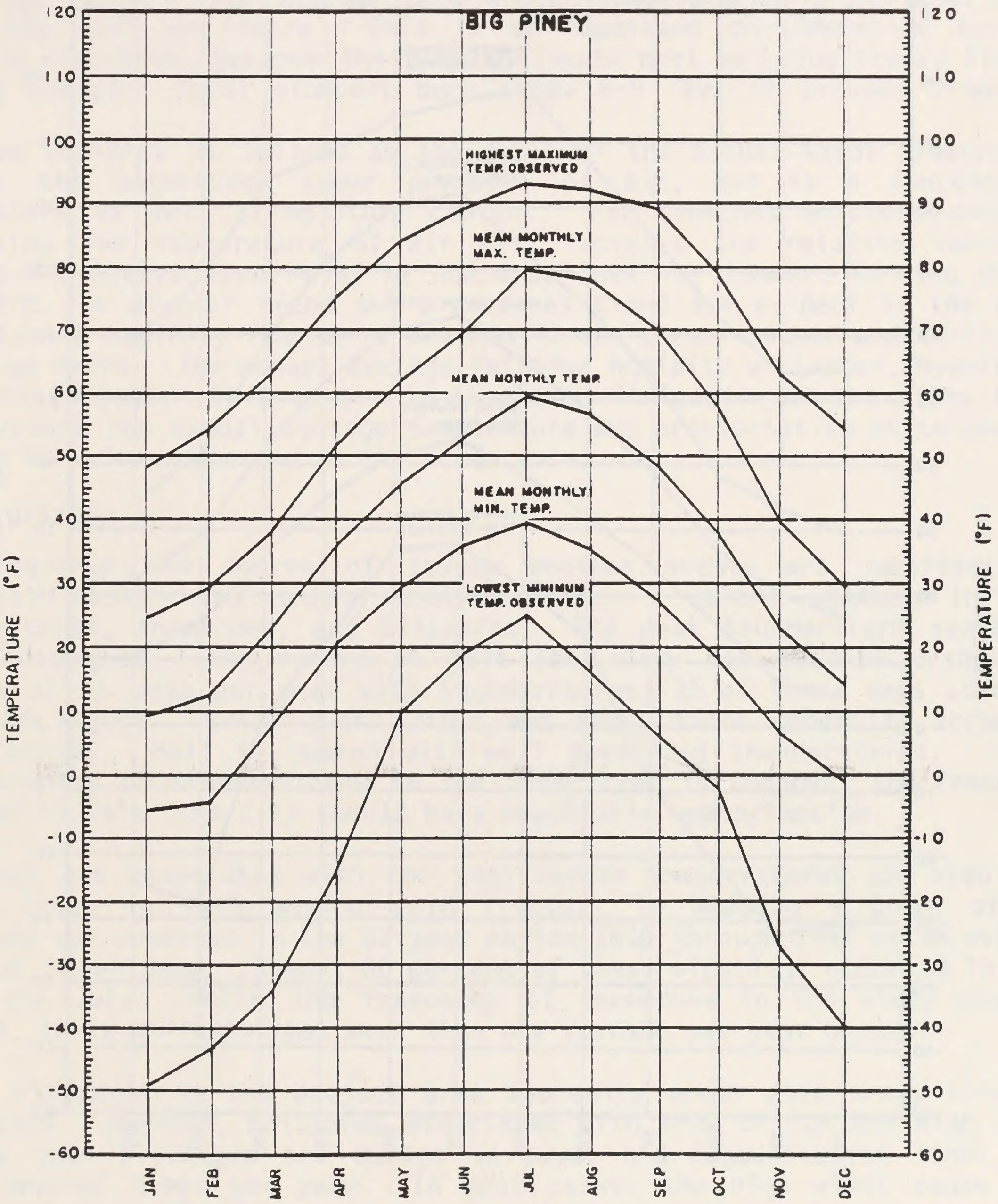
Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-11 ROCK SPRINGS WIND ROSE (1967-1975) STABILITY CLASS D



Source: National Climatic Center
Asheville, North Carolina

FIGURE 1-12 ROCK SPRINGS WIND ROSE (1967-1975) STABILITY CLASSES E-F



ELEVATION = 6820 FT.
PERIOD OF RECORD = 23 YRS.

FIGURE 1-13 MEAN AND EXTREME TEMPERATURES: BIG PINEY

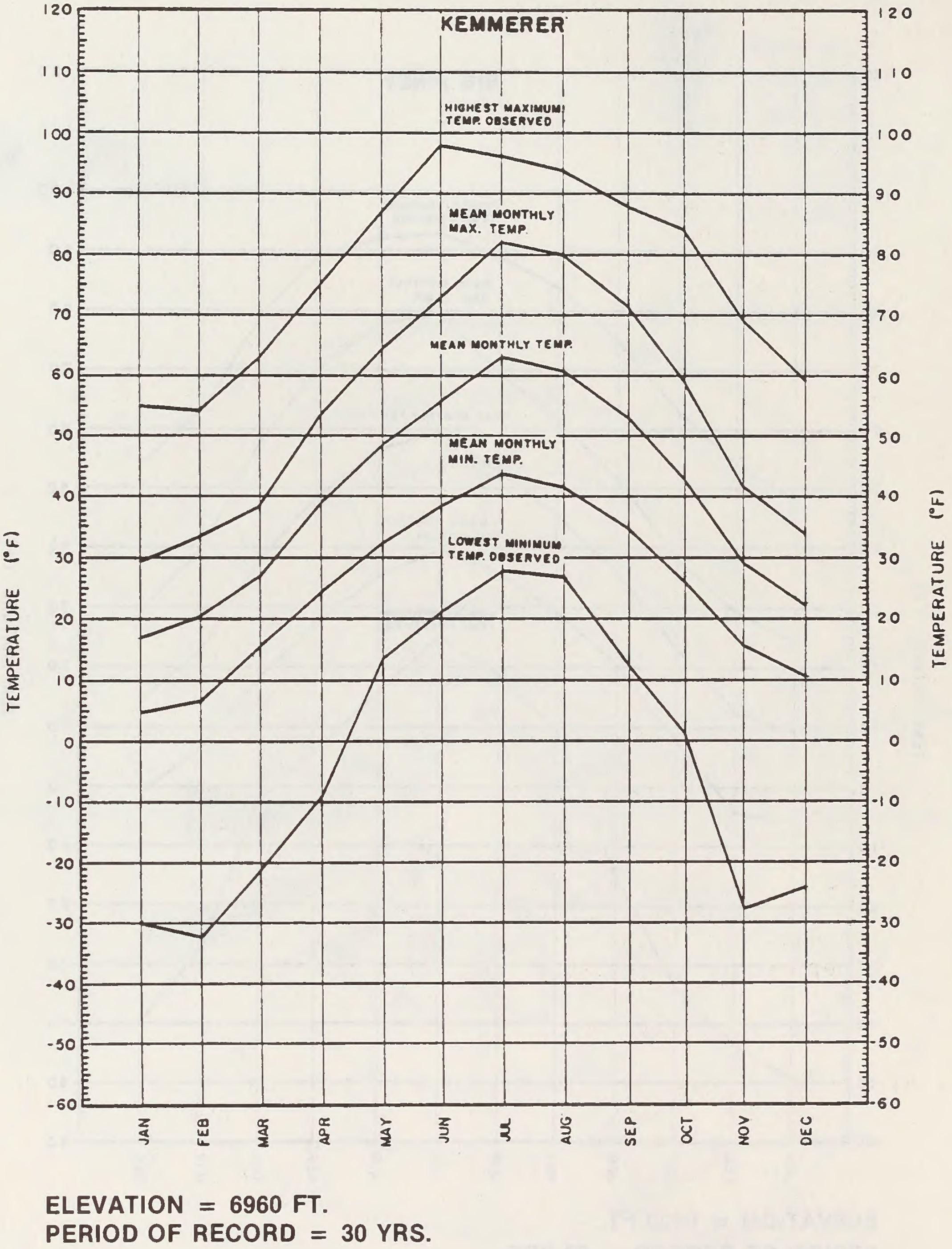


FIGURE 1-14 MEAN AND EXTREME TEMPERATURES: KEMMERER

March. Mean monthly maximum temperatures range from 25°F in January to 80°F in July and mean monthly minimum values range from -5°F to 40°F. Average nighttime minimum temperatures are below freezing in all months except June, July, and August. The extreme cold winter temperatures in the area often cause the soil to freeze. This is an important consideration for gas pipeline placement, because the pipeline depth must be below freeze line to prevent damage. Local plumbers bury pipes 6-8 feet to prevent freezing.

Relative humidity is defined as the ratio of the actual vapor pressure of air to the saturation vapor pressure of air, and is a function of temperature as well as moisture content. For constant moisture content, decreasing the temperature of air will increase the relative humidity. Table 1-6 presents mean relative humidity data for Lander, Wyoming during 1974-1978. A diurnal trend and a seasonal trend are evident in the data. The relative humidity reaches a maximum in the winter season and during the nighttime hours. The annual average relative humidity at Lander, Wyoming is about 53 percent. This generally should be indicative of the Riley Ridge area because the annual average temperature and precipitation at Lander are similar to values recorded in the study area.

SEVERE WEATHER

The frequency and degree of severe weather events are important for potential health and safety considerations. Severe weather includes thunderstorms, tornadoes, and blizzards. The peak thunderstorm season is July and August. The record at Salt Lake City for 1929-1977 shows an average of 35 days per year with thunderstorms; 15 of these days occur in July and August. Brief gusty winds and heavy rains generally accompany thunderstorms. Hail is common with well developed thunderstorms. While the frequency of thunderstorms in the study area is unknown, the frequency reported at Salt Lake City should be a reasonable approximation.

Tornadoes are associated with the most severe thunderstorms and also with squall lines in fast moving cold fronts. In Wyoming a total of 165 tornadoes was observed in the 52-year period 1916 through 1967 or an average of about 3 per year. Almost 90 percent of these sightings occurred in May, June, and July. While the frequency of tornadoes in the study area is unknown, it is unlikely that more than one tornado per year occurs.

Severe blizzards in the project area typically occur once every three to four years. However, blizzards associated with snow drifts and high winds causing road blockages and damage to power and communication lines, can occur several times per year. In most cases, the high winds cause more damage and disruption than does the amount of snowfall.

BASELINE AIR QUALITY AND VISIBILITY

EXISTING AIR QUALITY

Air quality in the Riley Ridge study area is generally good. Available air quality data for the gaseous air pollutants sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and carbon monoxide (CO) indicate relatively low mean concentrations. Monitored ambient concentrations of particulates are generally not as low, and may in some cases be attributable to natural sources of wind-blown dust or strong local influences.

TABLE 1-6

AVERAGE RELATIVE HUMIDITY AT LANDER, WYOMING

Local Time:	0500	1100	1700	2300	Average
Jan	66	59	59	65	62.3
Feb	67	57	54	65	60.8
Mar	66	51	47	61	56.3
Apr	67	46	41	59	53.3
May	67	44	38	57	51.5
Jun	64	41	33	52	47.5
Jul	56	34	28	44	40.5
Aug	54	33	27	43	39.3
Sep	60	38	33	50	45.3
Oct	64	45	42	57	52.0
Nov	69	57	57	66	62.3
Dec	68	60	61	67	64.0
Annual	64	47	43	57	52.8
Winter	67	59	57	66	62.3
Spring	67	51	42	59	54.8
Summer	58	36	29	46	42.3
Fall	64	47	44	58	53.3

Source: National Oceanic and Atmospheric Administration

[1] Data from 1947 - 1978

Emissions from existing facilities are dispersed throughout the study area which affect current local and regional air quality. The quality of the air in the study area can be determined from measurements of ambient air pollutant concentrations which is discussed in detail in subsequent paragraphs. Map 1-1 (map pocket) shows the locations of all large existing sources identified in the Riley Ridge study area; Table 1-7 lists their estimated emissions of SO_2, NO_x, and particulates. Except for the Big Piney Compressor Station and existing field compressor units, these emissions were provided by the Wyoming Department of Environmental Quality (DEQ). Big Piney and field compressor emissions were obtained from Northwest Pipeline. The largest existing source in the vicinity of the Craven Creek and Shute Creek sites is Utah Power and Light's Naughton Power Plant southwest of Kemmerer. This facility consists of three coal-fired electric generating units with a combined rating of approximately 700 megawatts. The largest source in the immediate area of the West Dry Basin, East Dry Basin, and Big Mesa plant sites is Northwest's nominal 12,000-horsepower Big Piney Compressor Station. This is primarily a source of NO_x (oxides of nitrogen) and CO. In addition to the Big Piney Compressor Station, numerous heaters and compressors emitting small amounts of NO_x and CO are present in the existing sweet gas fields in the northern portion of the Riley Ridge study area.

Note that Table 1-7 contains emission rates for the Whitney Canyon and Carter Creek gas treatment plants. Since these sources have only recently begun operation, their emissions have not contributed to the historic air quality measurements discussed in the following paragraphs (whereas the other sources in Table 1-7 have). The potential for the cumulative impacts of Whitney Canyon and Carter Creek SO_2 emissions with SO_2 emissions from the Riley Ridge Project are discussed in Chapter 2.

A listing of the long-term average pollutant concentrations in the vicinity of the Riley Ridge Project area is presented in Table 1-8. The locations of the various monitoring sites are shown in Map 1-1 (map pocket). Total Suspended Particulate (TSP) values range from 9 to 34 micrograms/cubic meter; NO_2 values range from 3 to 9 micrograms/cubic meter; and SO_2 concentrations range from 1 to 3 micrograms/cubic meter. Based on the TSP values listed in Table 1-8, 30 micrograms/cubic meter is considered a reasonably conservative estimate of existing annual TSP background for the Riley Ridge study area. Measured SO_2 and NO_2 annual averages are quite low (at about the minimum sensitivity of the analysers). Based on the values in Table 1-8, conservative estimates of annual average background are 3 micrograms/cubic meter for SO_2 and 9 micrograms/cubic meter for NO_2.

Annual background NO_2 levels at the northern Riley Ridge sites are probably higher than at the Craven Creek and Shute Creek sites because of the presence of the Big Piney Compressor Station and other sources of NO_x discussed above. Therefore, a check was made of the representativeness of the chosen 9 micrograms/cubic meter annual NO_2 value to assure that it is not too low an estimate for the northern proposed Riley Ridge gas treatment plant sites. EPA's ISC model was used to model the NO_x emissions from the Big Piney Compressor Station (treated as a volume source) with the Fort Bridger stability wind rose. A ventilated box model was used to assess the field compressor NO_x emissions, with annual average estimates of mixing height (about 1,325 meters) and wind speed (about 4.3 meters/second). The

TABLE 1-7

EMISSIONS FOR EXISTING SOURCES IN THE RILEY RIDGE STUDY AREA (POUNDS/HOUR)

	Emissions		
Emissions Source	SO_2	NO_x	TSP
Naughton Power Plant (Allowable)[2]	5,894	5,018	1,517
Opal Gasoline Plant	0	150	0
Muddy Creek Station	0	16	0
Green River Station	0	153	0
PEPL Storm Station	0	16	0
FMC Coking	NA	NA	139
Kemmerer Coal (Allowable)[2]	0	0	269
Jim Bridger Power Plant (Allowable)[2]	5,522	14,056	2,438
Big Piney Compressor Station	NA	259	NA
Miscellaneous Big Piney Field Compressor Units and Dehydrators	NA	65	NA
Allied Chemical Trona	1,052	848	225
FMC Trona	806	820	330
Texas Gulf Trona	203	381	240
Stauffer Trona	20	153	175
Tenneco Trona	226	791	NA
Whitney Canyon Gas Treatment Plant[3]	3,117	0	0
Carter Creek Gas Treatment Plant[3]	34	0	0

[1] No data available.

[2] Allowable emissions refer to the maximum emission rate permitted by regulation. Actual plant emissions are generally below these levels.

[3] These sources have only recently begun operation. Their emissions, therefore, have not contributed to historic air quality measurements; however, because of its emissions, Whitney Canyon was included in the cumulative analysis in Chapter 2.

TABLE 1-8

ANNUAL AVERAGE MEASURED POLLUTANT CONCENTRATIONS IN THE RILEY RIDGE STUDY AREA

Pollutant	Concentration ($\mu g/m^3$)	Year	Data Source
TSP[1]	11-25[2]	1979-1980	Kemmerer Coal
	34	1978	WDEQ Grover
	24,34	1975,1976[3]	UP&L Naughton Plant
	29	1978-1979[3]	AMOCO Ryckman Creek
	28	1978	WDEQ Kemmerer
	9, 12, 10	1979, 1980, 1981	WDEQ Boulder
NO_2	9	1978	WDEQ Kemmerer
	3	1978-1979[3]	AMOCO Ryckman Creek
SO_2	3	1975-1976	UP&L Naughton Plant
	2	1978-1979[3]	AMOCO Ryckman Creek
	1	1978	WDEQ Kemmerer

---

[1] Annual geometric mean.

[2] The range is based on four monitoring locations.

[3] Eight-month average

screening model results indicate that annual average NO_2 concentrations (as NO_x) range from just over 9 micrograms/cubic meter in the vicinity of the Big Piney Compressor Station to less than 1 microgram/cubic meter in the vicinity of the field compressor units.

Maximum measured short-term SO_2, TSP, and CO data are summarized in Table 1-9. Available 24-hour SO_2 values range from 14 to 26 micrograms/cubic meter; 3-hour values range from 68 to 115 micrograms/cubic meter. Maximum measured 24-hour TSP concentrations vary sharply with season and location. The lowest of these values is 39 micrograms/cubic meter (measured in Boulder, Wyoming in 1980), while the highest is 218 micrograms/cubic meter (measured in 1980 at the Kemmerer Coal Mine). There are numerous measurements above the 150 micrograms/cubic meter ambient air standard (probably due to wind blown dust, local construction activities, or proximity to unpaved roads). Maximum measured CO concentrations are 3,336 micrograms/cubic meter and 1,381 micrograms/cubic meter for 1-hour and 8-hour averages, respectively. Since the short-term measurements are relatively far removed from the project sites, it is very difficult to estimate representative background short-term concentrations at the project sites. However, reasonably conservative short-term SO_2 concentrations are considered to be about 15 micrograms/cubic meter and 70 micrograms/cubic meter for 24-hour and 3-hour averages, respectively. A conservative estimate of background 24-hour TSP is 60 micrograms/cubic meter. Estimates of short-term background CO are not as important because the CO ambient standards are large in comparison to the CO emissions expected from the Riley Ridge Project. However, conservative CO estimates are considered to be 3,500 micrograms/cubic meter and 1,500 micrograms/cubic meter for 1-hour and 8-hour averages, respectively.

A summary of the ERT-estimated long-term and short-term background concentrations is given in Table 1-10. Note that these values are not considered applicable to existing concentrations in PSD Class I areas. While there are no data in the Bridger, Teton, and Fitzpatrick Wildernesses or the Grand Teton National Park, these areas can be assumed to have background air quality concentration values near zero.

EXISTING VISIBILITY

Visibility is a measure of atmospheric clarity. Establishment of baseline visibility is important when estimating impacts of the proposed Riley Ridge Project, especially in pristine PSD Class I areas. Visibility can be impaired by general air quality, in particular by stack emissions of sulfur oxides, nitrogen oxides, and particulates. Natural phenomena such as humidity, precipitation, blowing dust, and smoke and fog can also greatly reduce visibility. In the Riley Ridge area fog, precipitation, and blowing dust are probably the primary natural restrictions to visibility. At the higher elevations in the Bridger Wilderness, blowing dust is probably very rare, but ground-based fog and precipitation may cause natural visibility impairment.

The Federal Aeronautics Administration (FAA) visibility data at Rock Springs show that visibility in the air quality study area exceeds 25 miles roughly 80 percent of the time . The seasonal summary indicates visibility is best in the summer and worst in the winter. Conditions of visibility less than

TABLE 1-9

MAXIMUM MEASURED SHORT-TERM POLLUTANT CONCENTRATIONS IN THE RILEY RIDGE STUDY AREA

Pollutant	Averaging Time	Concentration (μg/m³)	Year	Data Source	
SO_2	24-Hour	26	1975-1976	UP&L	Naughton Plant
		14	1978-1979[1]	AMOCO	Ryckman Creek
	3-Hour	115	1975-1976	UP&L	Naughton Plant
		68	1978-1979[1]	AMOCO	Ryckman Creek
TSP	24-Hour	61-218	1979-1980		Kemmerer Coal
		110	1978	WDEQ	Grover
		103	1975-1976	UP&L	Naughton Plant
		201	1978-1979	AMOCO	Ryckman Creek
		53	1978	WDEQ	Kemmerer
		43, 47,39	1979, 1980, 1981	WDEQ	Boulder
CO	8-Hour	1,381	1978-1979[1]	AMOCO	Ryckman Creek
	1-Hour	3,336	1978-1979[1]	AMOCO	Ryckman Creek

[1] 8-month record

TABLE 1-10

ESTIMATES OF REPRESENTATIVE BACKGROUND (EXISTING) POLLUTANT LEVELS IN THE RILEY STUDY AREA[1] (MICROGRAMS/CUBIC METER)

Pollutant	Averaging Time	Background Concentration	WAAQS	NAAQS Primary	NAAQS Secondary
SO_2	3-Hour	70	1,300	-	1,300
	24-Hour	15	260	365	-
	Annual	3	60	80	-
NO_2	Annual	9	100	100	100
TSP	24-Hour	60	150	260	150
	Annual	30	60	75	60
CO	1-Hour	3,500	40,000	40,000	40,000
	8-Hour	1,500	10,000	10,000	10,000

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[1] Background pollutant levels estimated from available data sources. Sources include WDEQ monitors at Kemmerer, Grover, and Boulder; Amoco monitors at Ryckman Creek; Utah Power & Light monitors at the Naughton Power Plant; and monitors operated by Kemmerer Coal Company. See Tables 3-8 and 3-9 for details concerning pollutant levels at a particular station.

one mile (usually associated with heavy fog) occur approximately 4 percent of the time in winter and zero percent in summer.

According to the Workbook for Estimating Visibility Impairment (EPA 1980), the mean background (existing) visual range for the project area ranges from 170 kilometers near Kemmerer and points south, to 110 kilometers for points north of Kemmerer. The visual range is defined as the distance at which a black object is barely perceptible against the horizon sky. The larger the background visual range, the higher the potential for visibility degradation.

The National Park Service currently maintains visibility sites equipped with manual telephotometers and cameras in the Grand Teton and Yellowstone National Parks. A summary of this data is presented in Table 1-11, which shows selected percentiles of the standard visual range cumulative frequency distribution. The data from both sites are similar and indicate the mean background visual range is approximately 150 kilometers.

The Forest Service has taken photographs of various views in the Bridger Wilderness, however, these raw data have yet to be analyzed by the Forest Service.

TABLE 1-11

PERCENTILES OF THE STANDARD VISUAL RANGE CUMULATIVE FREQUENCY DISTRIBUTION AT YELLOWSTONE AND GRAND TETON NATIONAL PARKS (in Kilometers)

	10th	50th	90th Percentile
Yellowstone			
Fall 1981	77[1]	144	268
Summer 1981	99	163	267
Grand Teton			
Fall 1981	82	142	247
Summer 1981	93	144	222
Fall 1980	104	165	263
Summer 1980	96	151	239

Source: John Muir Institute Research Visibility Center, Fort Collins, Colorado.

[1] Interpreted as 10 percent of the time the standard visual range was 77 kilometers or less.

CHAPTER 2

ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

The proposed Riley Ridge Project would consist of numerous construction activities, and well field, plant, and pipeline operations which would emit various air pollutants including SO_2, NO_x, particulates, CO, VOC (nonmethane), hydrogen sulfide (H_2S), and carbonyl sulfide (COS). While helium (He) and carbon dioxide (CO_2) are not normally considered "pollutants", very high concentrations of these substances can result in significant health-related impacts.

The analytical techniques used to generate these results (see Chapter 3) varied slightly depending on the time average being modeled. These variations were necessitated by the suitability of different data sets for different modeling steps. Modeling of annual averages was conducted using off-site data from Fort Bridger. These data are available in a STAR summary form suitable for input into annual average models. Chapter 1 discusses the rationale behind the selection of Fort Bridger data for annual average modeling.

The modeling of short-term (24 hours or less) averages used two separate and independent data sets: 1) assumed "worst-case" meteorological data; and 2) actual off-site meteorological data from the Kemmerer Coal Company. Kemmerer Coal, rather than Fort Bridger, was selected as the short-term off-site data set because only the Kemmerer data contained the required hour-by-hour breakdown of meteorology (see Chapter 1 for more detail). These data sets were modeled because the on-site data (currently being collected) are not yet complete. Both the assumed "worst case" data and the actual off-site data generate a range of concentrations at each receptor. Subsequent tables in this section list the highest predicted concentrations using both data sets.

Because the assumed "worst-case" meteorological data do not account for the site-specific frequency and persistance of local meteorological condition (actual off-site data do a better job of this), more credence is placed on results predicted using actual (albeit off-site) data.

Air pollutant impacts can be judged "significant" or "insignificant" in an EIS framework using several sets of criteria. These significance criteria are discussed in more detail below.

NATIONAL AND WYOMING AMBIENT AIR QUALITY STANDARDS

The National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS) are important benchmarks of significant impact. Primary and secondary NAAQS and WAAQS have been issued for SO_2, NO_2, TSP, CO, O_3, lead, VOC, H_2S, and hydrogen fluoride (HF); these standards are summarized in Table 2-1. Primary standards are designed to protect public health, and secondary standards are designed to protect public welfare.

Annual average standards are never to be exceeded. Generally, short-term standards (24 hours or less) cannot be exceeded more than once per year. Exceptions to this are the Wyoming half-hour H_2S standards of 70 micrograms/cubic meter and 40 micrograms/cubic meter, which are not to be exceeded more than twice per year, and more than twice in any five consecutive days, respectively. Given this framework, a significant EIS impact would occur if any NAAQS or WAAQS were violated (except as noted below).

Assessment of compliance with NAAQS and WAAQS must account for total atmospheric burdens of the pollutant species of interest due to all natural and anthropogenic (man-made) emission sources. Therefore, temporary construction-related impacts as well as the more permanent operations-related impacts are subject to NAAQS and WAAQS compliance. However, emissions resulting from emergency upsets, start-up and shutdown activities (e.g., gas treatment process upset flares and diesel generators used only during emergency outage of electric power lines) are generally so short-term (on the order of hours to a few days) that they are exempted from compliance with ambient standards. Based on these criteria, construction-related and operations-related Riley Ridge Project impacts are compared to applicable NAAQS and WAAQS to determine whether the impacts are significant.

Areas currently in compliance with NAAQS and WAAQS are termed Attainment areas, and those areas not in compliance are designated Nonattainment areas. These determinations are made on a pollutant-by-pollutant basis by the Wyoming Department of Environmental Quality (WDEQ) with assistance from EPA. All portions of the Riley Ridge Project study area are Attainment for all pollutants, with the exception of the trona industrial area which is Nonattainment for TSP. The boundaries of the trona Nonattainment areas have been defined by the WDEQ based on modeled TSP concentrations. These areas approximately cover a 36-square mile area surrounding the Stauffer, FMC, and Allied Chemical trona plants. These areas are shown on Map 1-1.

New large pollutant sources in Attainment areas must show that the standards will be maintained. If new sources in attainment areas, such as the Riley Ridge Project, are also subject to Prevention of Significant Deterioration (PSD) review (discussed in more detail in the next subsection) then applicable PSD increments must be met as well.

Sources which are in or may impact Nonattainment areas must demonstrate that their incremental impacts in the Nonattainment area will be below EPA's Significance Levels which are shown in Table 2-2. Based on the EPA TSP Significance Levels in Table 2-2, impacts at the trona TSP Nonattainment area from the Riley Ridge Project particulate emissions will be determined significant (in an EIS sense) if predicted TSP concentrations exceed the 1 microgram/cubic meter annual average. The EPA 24-hour significance level of 5 micrograms/cubic meter is not considered an applicable EIS significance criterion because the vast majority of Riley Ridge Project particulate emissions are construction-related fugitive dust. Twenty-four hour average concentrations from fugitive dust are generally not evaluated according to WDEQ guidelines because of modeling uncertainties.

TABLE 2-1

WYOMING AND NATIONAL AMBIENT AIR QUALITY STANDARDS[1]

Contaminants	Wyoming Standards ($\mu g/m^3$)	National Standards ($\mu g/m^3$) Primary	Secondary
TSP			
24-Hour[2]	150	260	150
Annual[3]	60	75	60
SO_2			
3-Hour[2]	1,300	--	1,300
24-Hour[2]	260	365	--
Annual[4]	60	80	--
NO_2			
Annual[4]	100	100	100
CO			
1-Hour[2]	40,000	40,000	40,000
8-Hour[2]	10,000	10,000	10,000
H_2S[5]			
0.5-Hour[6]	70	--	--
0.5-Hour[7]	40	--	--
HF[5]			
24-Hour	0.8	--	--
Photochemical Oxidants (O_3)			
1-Hour	160	235	235
VOC (Nonmethane)[8]			
3-Hour[2]	160	--	--
Lead			
3-Month	1.5	1.5	1.5

---

[1] Temporary construction-related emissions are well as the more permanent operations-related impacts are subject to NAAQS and WAAQS. However, emissions resulting from emergency upsets and start-up and shut-down activities are exempted from NAAQS and WAAQS compliance.

[2] Not to be exceeded more than once per year.

[3] Annual geometric mean, never to be exceeded.

[4] Annual arithmetic mean, never to be exceeded.

[5] Wyoming ambient standard only.

[6] Not to be exceeded more than twice per year.

[7] Not to be exceeded more than twice in any five consecutive days.

[8] Wyoming ambient standard. Federal hydrocarbon standard was repealed by EPA on January 5, 1983.

TABLE 2-2

EPA SIGNIFICANCE LEVELS FOR NONATTAINMENT AREAS

(μg/m^3)

Pollutant	Annual	24-Hour	8-Hour	3-Hour	1-Hour
Sulfur Dioxide	1	5	--	25	--
Total Suspended Particulate	1	5	--	--	--
Nitrogen Dioxide	1	--	--	--	--
Carbon Monoxide	--	--	500	--	2,000

Source: Prevention of Significant Deterioration Workshop Manual, Environmental Protection Agency, October 1980b.

PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS

PSD regulations in Wyoming establish air quality increments for SO_2 and TSP that restrict deterioration by major sources. The applicable SO_2 and TSP PSD increments are shown in Table 2-3. Note that the PSD increments are much smaller than corresponding NAAQS and WAAQS; therefore, the increments are often more limiting in determining the size of new projects that may be built. The amount of deterioration by new sources is determined by the classification of the area. Presently, the entire area surrounding the proposed project is designated as PSD Class II, which allows for moderate air quality deterioration. Map 1-1 (map pocket) also shows existing and proposed PSD Class I areas. Little air quality deterioration is allowed in PSD Class I areas. The closest existing Class I area is the Bridger Wilderness located approximately 75 kilometers (50 miles) northeast of the well field and about 120 kilometers (75 miles) east-northeast of the Craven and Shute Creek sites. Table 2-4 lists the distance from all proposed plant sites to each proposed or existing Class I areas.

Annual average increments are never to be exceeded. However, short-term increments may be exceeded once per year in all areas. This is important in establishing the significance of short-term impacts because it means the absolute highest value at all locations (i.e., receptors) can be ignored when evaluating the results. Instead, to determine compliance with the short-term PSD increments, the highest concentration remaining, termed the "highest second highest", must be equal to or less than the applicable increment. In other words, if the maximum concentration exceeds the increment, but the highest second highest concentration does not, impacts are not deemed significant.

The PSD increments in Table 2-3 apply only to routinely operating sources such as the gas treatment plants. They do not apply to temporary sources as defined by EPA (1980c) which "typically include, but are not limited to, emissions from a pilot plant, a portable facility, construction or exploration activities". Examples of temporary sources in the Riley Ridge Project would include the construction of plants and pipelines, and well field drilling operations. (Justification for defining these sources as temporary, is presented in subsequent sections).

Although project impacts are compared to PSD increments, this analysis is not a substitute for the PSD permit analysis. That review is handled independently by the WDEQ. The on-site data currently being collected should be used to evaluate impacts.

CO_2, COS, AND HE SIGNIFICANCE CRITERIA

The Riley Ridge Project may emit CO_2, He, and COS if CO_2 and He-rich streams are vented to the atmosphere, rather than purified and sold. (The magnitude of these emissions are listed in Tables 3-1 through 3-6.) The American Council of Governmental Industrial Hygienists (ACGIH 1980) has established Threshold Limit Values (TLV) for various chemical substances and physical agents including CO_2, but not COS and He. The following has been paraphrased from the ACGIH document:

> Threshold limit values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day

TABLE 2-3

PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS[1]

($\mu g/m^3$)

Averaging Period	Class I[2]	Class II[3]
Sulfur Dioxide		
Annual	2	20
24-Hour[4]	5	91
3-Hour[4]	25	512
Total Suspended Particulates		
Annual	5	19
24-Hour[4]	10	37

---

[1] PSD increments apply only to permanent sources. Temporary emissions (such as construction or well drilling) are not regulated by PSD.

[2] Class I areas include the Bridger, Fitzpatrick, Teton Wilderness, and Grand Teton National Park. Scab Creek and Popo Agie Primitive Area and Fossil Buttes National Monument are proposed Class I areas, but currently regulated by Class II increments. The Class I PSD increments can be waived if it is demonstrated to the satisfaction of federal land manager that the air quality related values (AQRV) of the Class I areas are not adversly impacted. On the other hand, a PSD permit may be denied if AQRV are adversely impacted, even if Class I increments are met.

[3] Areas surrounding the Riley Ridge Project are Class II.

[4] All 24- and 3-hour values may be exceeded once per year.

TABLE 2-4

APPROXIMATE DISTANCES TO PROPOSED OR EXISTING CLASS I AREAS

		Distance From Plant Site (Km)					
Class I Area	Status	Big Mesa	East Dry Basin	West Dry Basin	Craven Creek	Shute Creek	Buckhorn Creek
Bridger Wilderness	Existing	80	65	75	120	115	55
Teton Wilderness	Existing	160	150	150	215	210	150
Teton National Park	Existing	150	140	140	205	205	155
Scab Creek Primitive Area	Proposed	75	60	70	120	110	50
Fossil Buttes National Monument	Proposed	70	80	75	40	50	90

> without adverse effect. Threshold limit values refer to time-weighted concentrations for a 7- or 8-hour workday and 40-hour workweek. They are generally used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations. Time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday.
>
> Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form the basis for others.
>
> In spite of the fact that serious injury is not believed likely as a result of exposure to the threshold limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

The TLV for CO_2 is 5,000 parts/million, 8-hour average. Because the time-weighted average discussed by the ACGIH applies to CO_2, in effect the annual average exposure of workers to CO_2 should not exceed 5,000 parts/million. Therefore, an annual average of 5,000 parts/million is used as an appropriate EIS significance criterion for CO_2.

Helium, an inert gas, is classified by the ACGIH as a "simple asphyxiant". A TLV is not an appropriate concept for simple asphyxiants because the limiting factor to potential worker hazard is the available oxygen. According to the ACGIH, the minimal oxygen content should be 18 percent by volume to prevent asphyxiation. In a normal atmosphere, it is about 21 percent. Therefore, the ambient He concentrations from venting would have to be about 30,000 parts/million to displace oxygen from 21 percent to 18 percent by volume. This concentration is used as the EIS significance criterion for He.

A TLV has not been established for COS because there is very little data available on the health and environmental impacts of COS. Acute exposures to high concentrations of COS can result in death by respiratory paralysis caused by COS acting on the central nervous system (SRI 1976). No chronic studies involving animals have been reported, nor have human exposures been documented (SRI 1976). Little is known of the biological mechanisms of COS toxicity, although it has been hypothesized that COS is probably similar to CS_2 in this regard, with both involving oxidative sulfur species (SRI 1976).

Given the lack of health effects data for COS, there are a number of approaches which have been taken to develop suggested criteria for ambient COS exposures. None of these criteria have official status, however. There are no federal standards for ambient or occupational exposures to COS, nor are there privately recommended occupational exposures.

The EPA has suggested a multimedia environmental goal (MEG) of 800 micrograms/cubic meter for long-term ambient exposures to COS based on human health effects (EPA 1977). This value was derived using standard MEG procedures from a reported lowest lethal dose in mice of 2,900 parts/million over 24 hours. Therefore, an annual average of 800 micrograms/cubic meter of COS is used as the EIS significance criterion.

For short-term exposures, the following can be used. Based on the presumed analogy between COS and CS_2 toxicity, which is often mentioned in the literature, the 8-hour TLV of 10 parts/million recommended by the ACGIH for CS_2 may be relevant (ACGIH 1980). Accepting SRI's hypothesis that CS_2 is twice as toxic as COS on a molar basis (because an oxidative sulfur species is presumably the active agent), then a corresponding 8-hour TLV for COS would be 20 parts/million (60,000 micrograms/cubic meter at the Riley Ridge sites). This value is used as the short-term COS significance criterion for the Riley Ridge EIS.

AIR QUALITY RELATED VALUES - CLASS I AREAS

In addition to the significant air quality impact criteria discussed above the FS has identified eight Air Quality Related Values (AQRV) for the wilderness and primitive areas under its jurisdiction. While quantitative significance criteria are yet to be identified by the FS to determine whether significant impacts could occur to the AQRV, the FS has identified physical parameters for each AQRV whose changes can ultimately be used to judge whether significant impacts could occur as a result of changes in air quality. The parameters for each of the eight AQRV include:

- AQRV - Flora and Fauna. Changes in the parameters:

    - Growth
    - Mortality
    - Reproduction
    - Diversity
    - Visible injury
    - Succession
    - Productivity

- AQRV - Soil. Changes in the parameters:

    - Cation exchange capacity
    - Base saturation percent
    - pH
    - Structure
    - Metals concentration

- AQRV - Water. Changes in the parameters:

    - pH
    - Metals concentration
    - Total alkalinity

- AQRV - Visibility. Changes in the parameters:
    - Contrast
    - Coloration
    - Visual range
- AQRV - Odor. Changes in the parameters:
    - Odor
- AQRV - Cultural/Archeological. Changes in the parameters:
    - Deposition
    - Decomposition
- AQRV - Geologic. Changes in the parameters:
    - Deposition
    - Decompositon

For the purposes of this EIS AQRV significance criteria have been developed for: 1) pH changes in sensitive lakes from acid deposition, 2) contrast, coloration and visual range changes related to visibility impairment, 3) visible injury to sensitive vegetation, and 4) detectable odor thesholds of H_2S. These significance criteria are discussed in the following paragraphs.

Acid Deposition Significance Criteria

The SO_2 and NO_x emissions from the proposed Riley Ridge Project may result in deposition of acidic species in pristine areas, particularly the Bridger Wilderness. Of potential concern is whether such acid deposition in high-altitude, low-buffered lakes would result in the population decrease of existing golden, rainbow, and brook trout. The decrease in Bridger trout populations from acid deposition would be initiated by reproduction difficulties which is assumed to be a significant EIS impact.

Table 2-5 presents pH ranges at which reproductive failure occurs in brook and rainbow trout, which are taken from Haines and Schofield (1980). Data are not available for golden trout. The values in Table 2-5 show that reproductive failure can occur for brook trout when the stream pH ranges from 4.5 to 5.0. Similarly, reproductive problems in rainbow trout can occur with lake pH values of 5.5 to 6.0. These ranges can be used to estimate the pH levels that could cause reproductive problems in the Bridger lakes. Therefore, a reasonable EIS significance value is considered to be a pH change down to 6.0. This value, at the upper end of the range of documented impacts, should be conservative enough to also indirectly account for the potential leaching of toxic heavy metals, such as aluminum, from surrounding terrain due to acid runoff.

Visibility Impairment Significance Criteria

The SO_2, NO_x, and TSP emissions from the project may result in visibility impairment in the PSD Class I areas. According to EPA's Workbook for Estimating Visibility Impairment, significant visibility impact could occur if "Level 1" calculations show that any of the parameters "C_1", "C_2", or

TABLE 2-5

FIELD pH AT WHICH REPRODUCTIVE FAILURE OCCURS

Species	Field pH[1]
Brook Trout	4.5 - 5.0
Rainbow Trout	5.5 - 6.0

Source: Responses of Fish to Acidification of Streams and Lakes in Eastern North America. Haines and Schofield 1980.

[1] pH range is that at which the species has been reported to disappear.

"C_3" is equal to or greater than 0.1 in absolute value. C_1 represents the plume-sky contrast; C_2 represents the sky-terrain contrast caused by particulates and NO_2; and C_3 is the change in sky-terrain contrast caused by secondary aerosols. According to PSD rules, the visibility impairment analysis should include operating emissions but not emissions from temporary or construction-related sources.

Vegetation Significance Criteria

Particulates are generally not considered to be pollutants which produce significant environmental impacts on vegetation. Literature data which assess the impacts of particulates on vegetation are quite limited. Generalized impact assessments for particulates are difficult to conduct since the chemical composition, deposition rate, and solubility of potentially toxic elements must be known in order to evaluate the potential impact of these emissions. Particulate deposition on vegetation should result in only a superficial coating which is subject to removal by wind and rain. Since available data at this time do not indicate that particulate emissions will be of environmental concern, it is assumed that significant impacts from particulates to vegetation in Class I areas are unlikely if TSP impacts are below the applicable PSD Class I increments.

In the Bridger Wilderness and other proposed and existing PSD Class I areas, lichens should be the most sensitive vegetative species to SO_2. While it is not known what types of lichen species exist in the proposed and existing Class I areas surrounding the Riley Ridge Project, data recently collected for the Forest Service in the Flat Tops Wilderness (Hale 1982) can be used as a general indication of what might be found in the Bridger and Teton Wildernesses, Teton National Park, and the Scab Creek Primitive Area. According to that report, a total of 137 lichen species were studied, representing 16 fruticose species, 47 foliose, and 74 crustose species. Le Blanc and Rao (1975) state that crustose lichen growth forms are generally more resistant to SO_2 injury than foliose and fruticose lichen types. Le Blanc and Rao (1973) have also established SO_2 levels which they believe represent thresholds for injury to lichens. They proposed long-term average concentrations of 0.03 parts/million as an acute injury threshold and concentrations between 0.006 and 0.03 parts/million as a chronic injury threshold. For the average barometric pressure and temperature in the Bridger Wilderness (assumed to be about 520 millimeters mercury and -5°C), concentrations of 0.03 and 0.006 parts/ million SO_2 are equivalent to about 60 and 12 micrograms/cubic meter, respectively. Therefore, short-term SO_2 should not exceed 60 micrograms/cubic meter and annual average SO_2 concentrations should not exceed 12 micrograms/cubic meter. Since these concentrations are well above short-term and annual Class I increments (see Table 2-3), it is assumed that insignificant impacts to lichens and other vegetation would occur if SO_2 impacts comply with applicable PSD Class I increments.

Odor Significance Criteria

Hydrogen sulfide can be detected as an odor at very small concentrations. However, the odor threshold varies significantly from person to person. Data presented by Leonardos et al. (1969) indicate an order of magnitude range of 0.00047 to 0.0047 parts/million. Data gathered by Wilby (1969) supports an H_2S odor threshold of 0.045 parts/million. Based on this very wide data range, a middle-of-the-range value is considered reasonable as an EIS significance criterion. Note that the Wyoming H_2S ambient standards of 40 and 70 micrograms/cubic meter, half hour averages, were designed to help mitigate the odor of H_2S as a nuisance. However, these concentrations are equivalent to approximately 0.0027 and 0.0047 parts/million, respectively. They are at the upper end of the range quoted above. Therefore, for the purposes of this EIS, the more conservative 0.0047 parts/million (about 6.5 micrograms/cubic meter) is used as the significance criterion for odor impacts from H_2S.

IMPACTS OF THE PROPOSED ACTION

This section summarizes the predicted maximum air quality impacts from the proposed Riley Ridge Project construction and operational activities and compares the impacts to applicable significance criteria discussed previously. The next four subsections present results for the proposed well drilling activities, gas treatment plant construction, operation of the well field, and operation of the gas treatment plants. Within each of these subsections, impacts are discussed pollutant by pollutant.

The Proposed Action consists of the construction of four separate gas treatment plants and related sour gas pipelines, sales gas pipelines, and molten sulfur terminal. Exxon proposes to build two identical facilities, each processing 600 million SCFD of sour, low-Btu gas. One facility would be constructed at the Big Mesa site, the other at the West Dry Basin site. American Quasar proposes to construct a similar plant to process 1.2 billion SCFD of sour, low-Btu gas at the East Dry Basin site. A 400 million SCFD plant is proposed by Northwest at the Craven Creek site. These sites are shown on Map 1-1 (map pocket).

PROPOSED WELL DRILLING OPERATIONS

Proposed well drilling operations are quite extensive and would occur for many years. Even though aggregate well drilling activities would occur for several years in the same area, emissions from such activities are considered temporary in a PSD sense for the following reasons:

1) Well drilling is analagous to a construction activity since the hole must be "constructed" in order to extract the gas. Extraction of the gas is analagous to an operating activity.

2) Well drilling activities at each well pad would occur for a period less than a year.

3) The drilling rig and ancillary equipment (including the diesel generators) are portable.

A detailed discussion of the emissions inventory associated with well drilling is contained in Chapter 3. The primary sources of emissions are the diesel generators at each well pad which operate about 230 days per year for single wells and about 290 days per year for Exxon's directional drilling alternative. (H_2S emissions would also result in the very unlikely event of a well blowout. This potential impact is discussed in detail in the Health and Safety Section of the EIS.)

Oxides of nitrogen are emitted in the largest quantities, followed by particulates and then SO_2. For this reason the modeling analysis focused on annual average NO_2 concentrations although annual average TSP and SO_2 concentrations were also estimated.

Maximum modeled impacts occurr at high terrain in the immediate vicinity of the well pad. Where well pads are in less complex terrain, predicted impacts are lower.

Combined impacts from multiple well drilling activities do not produce higher impacts than do single well drilling activities. There are two primary reasons which support this finding. First, well pads are spatially separated and maximum impacts occur very near individual well pads. This indicates single well pad impacts are responsible and that sufficient dilution occurs to minimize contributions from adjacent well sites. Second, most well pads are located at varying elevations. This produces a plume separation in the vertical which minimizes multiple impacts from adjacent wells.

Table 2-6 shows the maximum predicted NO_2, SO_2, and TSP impacts, existing background concentrations (discussed in Chapter 1), and total predicted concentrations. These are below the applicable NAAQS/WAAQS, resulting in insignificant impact. However, initially, maximum modeled NO_2 concentrations (assuming that all NO emissions are converted to NO_2) were above the 100 micrograms/cubic meter NAAQS/WAAQS for all companies. These modeled NO_2 concentrations are conservatively high because all NO emissions cannot be converted to NO_2 if insufficient ambient O_3 exists to oxidize the NO to NO_2 via the reaction:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Therefore, a more sophisticated NO_2 modeling analysis was performed which is described in more detail in Chapter 3. In essence, the "Ozone Limiting Method" (Cole and Summerhays 1979), was used in conjunction with ambient O_3 data, measured by the Wyoming Department of Environmental Quality near Patric Draw (about 10 miles east of Rock Springs), to estimate the amount of NO emissions converted to NO_2. The results of this modeling are presented in Table 2-6 and show that the maximum NO_2 impact is expected from Exxon's well drilling activity. The modeled maximum annual average NO_2 concentration, after accounting for O_3 as the limiting reactant, is 57 micrograms/cubic meter; and when combined with the background concentration of 9 micrograms/cubic meter, the total maximum NO_2 burden is 66 micrograms/cubic meter. Since this maximum NO_2 concentration is below the 100 microgram/cubic meter NAAQS/WAAQS, insignificant NO_2 impact is expected from all Riley Ridge well drilling operations.

Construction of well field access roads and well pads would result in fugitive dust. Calculated emissions for these operations (total for all activities) are Exxon: 54 tons per year, Northwest and Mobil: 8 tons per year, American Quasar: 34 tons per year, and Williams Exploration: 14 tons per year. Maximum annual TSP concentrations were modeled for typical Exxon, Mobil, and American Quasar well sites. The maximum modeled concentrations range from 0.6 micrograms/cubic meter to 2.1 micrograms/cubic meter depending on the company. These concentrations added to the background TSP

TABLE 2-6

MAXIMUM ANNUAL AVERAGE CONCENTRATIONS FROM DIESEL GENERATOR EMISSIONS (MICROGRAMS/CUBIC METER)

Company	NO_2[1]				SO_2				TSP			
	Modeled[2]	Background	Total	NAAQS/ WAAQS	Modeled[2]	Background	Total	NAAQS/ WAAQS[5]	Modeled[2]	Background	Total	NAAQS/ WAAQS[6]
American Quasar	7-50	9	16-59	100	2-13	3	5-18	60	2-14	30	32-44	60
Exxon[3]	32-45	9	41-54	100	7-10	3	10-13	60	8-11	30	38-41	60
Mobil	54	9	63	100	18	3	21	60	18	30	48	60
Williams Exploration[4]	--	9	--	100	--	3	--	60	--	30	--	60

[1] Modeled NO was converted to NO_2 according to the Ozone Limiting Method.

[2] Ranges given represent maximum impacts at different well drilling sites modeled. Mobil drills only one well per year; therefore only the "worst-case" site was modeled.

[3] Represents Exxon's proposed action of single well drilling per site for about 230 days per year.

[4] Not explicitly modeled due to lack of information. However, impacts from Williams Exploration should be similar to those of the other companies.

[5] WAAQS is presented because it is more stringent. The NAAQS is 80 micrograms/cubic meter.

[6] WAAQS and secondary NAAQS. Primary NAAQS is 75 micrograms/cubic meter.

concentration of 30 micrograms/cubic meter are still below the secondary ambient standard of 60 micrograms/cubic meter. Concentrations of TSP from multiple construction operations are not expected to greatly exceed the impacts listed above because the well pads are scattered throughout the well field area and are not concentrated at any one location. (This reasoning is discussed in more detail in the section on Gas Treatment Plant construction.)

Even though the fugitive dust emissions are not expected to result in significant TSP impacts, the dust would result in temporary and localized reduction in visibility. However, this is not expected to be significant. These construction activities would also result in emissions of NO_x, SO_2, and CO from vehicular exhaust. However, maximum concentrations of these pollutants from the exhaust are not expected to cause or contribute to significant impacts.

Note that emissions from Williams Exploration well drilling activities were not explicitly modeled for SO_2, NO_x, or TSP; however, maximum concentrations of these pollutants from their well drilling activities should be similar to those modeled for Exxon, Mobil, and American Quasar.

Based on the results presented above, the well drilling activities and access road construction are not expected to result in any significant air quality impacts.

GAS TREATMENT PLANT CONSTRUCTION

The major source of air pollution during construction of the plants, pipelines, access roads, and sulfur loadout facilities would be fugitive dust. Emissions from vehicular exhaust would also occur, but would be much smaller in magnitude, and it is assumed they would not cause any significant impacts. Fugitive dust emissions from the various earth-moving activities have been quantified and modeled according to the techniques described in Chapter 3. Exxon emissions are expected to peak at 325 tons/year in 1981 and 1988, Northwest emissions should reach 557 tons/year in 1984, and American Quasar would generate 129 tons/year in 1985 and 1987.

Table 2-7 summarizes the maximum modeled TSP concentrations for the Proposed Action. The modeling results indicate that maximum TSP impacts occur in the immediate vicinity of the gas treatment plant boundaries and decrease rapidly with increasing distance downwind. This is primarily attributable to low emission heights and the nonbuoyant nature of the plumes, as well as the fallout of particulate matter. When combined with the background value of 30 micrograms/cubic meter, all maximum concentrations are below the 60 micrograms/cubic meter NAAQS/WAAQS and are insignificant. The highest impacts (47 micrograms/cubic meter) are predicted to occur in the vicinity of the proposed Northwest facility at Craven Creek.

The construction of the gas treatment plants is expected to generate larger impacts than the construction of other facilities. Construction emissions associated with activities such as the above-ground molten sulfur line, CO_2 pipelines, and the railroad component alternative are smaller and spread out over a wider area. Therefore, these activities were not explicitly modeled. Impacts from these emissions would be less than the more concentrated emissions from gas treatment plant construction.

TABLE 2-7

MAXIMUM MODELED TSP CONCENTRATIONS FROM CONSTRUCTION OF PROPOSED ACTION[1]

	Annual Average Concentration (μg/m³)			
Plant Site/Company	Modeled	Background	Total	NAAQS/WAAQS
West Dry Basin/Exxon	10	30	40	60
Big Mesa/Exxon	10	30	40	60
East Dry Basin/Am Quasar	5	30	35	60
Craven Creek/Northwest	17	30	47	60
Sulfur Loadout/Exxon-Am Quasar	2	30	32	60

[1] Impacts from concurrent construction activities at other sites are expected to add (at most) 1 microgram/cubic meter to these concentrations. This results in a maximum predicted impact of 48 micrograms/cubic meter at Craven Creek, below the 60 microgram/cubic meter NAAQS/WAAQS.

In addition, the nature of fugitive dust emissions results in no significant impacts from the combination of concurrent construction activities. Because fugitive dust plumes have low emission heights, are nonbuoyant, and the particles are large and settle out quickly, impacts decrease very rapidly with increasing downwind distance. Maximum TSP impacts at any one location are therefore dominated by a single source rather than a combination of many spatially separated sources. Based on the spatial separation of the plant sites (no sites are any closer than about 6 miles from each other), maximum increases to TSP impacts at a given facility due to fugitive dust emissions from other plant sites would be on the order of 1 microgram/cubic meter. Since the individual plant impacts do not approach the NAAQS/WAAQS level of 60 micrograms/cubic meter (the highest impact is 47 micrograms/cubic meter), there is very little potential for impacts greater than the NAAQS/WAAQS from multiple site construction activities. Therefore, although not specifically modeled, insignificant TSP impacts are expected from the combined effects of plant construction. TSP concentrations at the trona nonattainment area were modeled and predicted to be negligible and therefore insignificant.

Dust plumes would be visible from construction activities and would temporarily decrease local visibility. However, since these dust plumes would be temporary, and the dust would eventually settle, no significant impact is expected.

OPERATION OF THE WELL FIELD

The calculated emissions during well field operation are very small. For American Quasar and Exxon, normal operations should produce negligible emissions. Upset flaring at Exxon's dehydration units could generate some emissions (see next paragraph). For Northwest and Mobil, wellhead heaters are expected to generate a total of 0.09 tons/year of CO and 0.56 tons/year of NO_x. These emission rates are far below the de minimis emission levels of 100 tons/year CO and 40 tons/year NO_x. Therefore, resultant impacts from normal well field operations would be insignificant.

However, the flaring of Exxon's dehydration units during very infrequent upset conditions (about 1/2-hour/year/unit) would probably result in SO_2 emissions of 118 tons/year, which is above EPA's de minimis levels of 40 tons/year. Upset conditions result from the malfunction of the dehydration units, thus requiring flaring of the well field gas. Since emissions from upsets are exempt from complying with PSD increments and ambient standards, these impacts are not significant in that regulatory framework. Even so, in the immediate vicinity of the dehydration units, relatively high short-term SO_2 concentrations could occur. These may be high enough to exceed the 3-hour NAAQS/WAAQS of 1,300 micrograms/cubic meter. However, during typical meteorological dispersion conditions (moderate to strong wind speeds), these concentrations would decrease very rapidly with distance downwind. At Big Piney, Marbleton, or LaBarge, SO_2 concentrations under such wind speeds would likely be negligible. During calm conditions, atmospheric dilution of SO_2 would be much less. Effects on field workers could be significant if dehydration unit flaring occurs during such conditions. However, flaring would only occur about one-half hour per year per unit, and based on the frequency of calm or near calm winds observed at the Kemmerer Coal site, the probability of flaring occurring during calm winds is less than 1:100,000 for Exxon. Therefore, no significant impact is expected.

Mobil and Northwest well field flaring would occur on a more regular basis (about 1/2-hour every 18 days/well) resulting in a total of 180 tons/year of SO_2. This is also above EPA's de minimis emission level of 40 tons/year. These emissions are expected to exceed the 3-hour NAAQS/WAAQS of 1,300 micrograms/cubic meter during stable atmospheric conditions and low winds in the immediate vicinity of the dehydration units. However, the joint probability of Northwest's flaring and those meteorological conditions is only 3:10,000. Therefore, no significant impact is expected.

OPERATION OF THE GAS TREATMENT PLANTS

Sulfur Dioxide

As discussed in detail in Chapter 3, the incinerators that combust tail gas from the sulfur recovery units would emit relatively large quantities of SO_2. Their buoyant plumes were modeled according to procedures discussed in Chapter 3 to determine annual average concentrations and maximum short-term (3-hour and 24-hour) concentrations. Annual averages were determined with a statistical summary of the meteorological dispersion conditions, i.e., a stability wind rose. Maximum short-term averages were determined in two ways: first with assumptions regarding "worst-case" dispersion meteorology, and subsequently with available, offsite, hourly meteorological data. Concentrations were determined in proposed and existing PSD Class I areas and in Class II areas.

The maximum modeled SO_2 concentrations from the tail gas incinerators occurred in high terrain, i.e., terrain above stack top. Maximum short-term impacts in Class II areas are due to individual plants. Combined short-term impacts of plumes from multiple facilities do not produce higher concentrations. This is primarily because of significant differences in site elevations (the minimum difference is about 400 feet between East Dry Basin and West Dry Basin; the maximum difference is about 1,400 feet between Big Mesa and Craven Creek). This allows plumes from different plants to rise to different heights with little or no interaction until the plumes have travelled fairly far downwind. At such long downwind distances the plumes have grown significantly in the vertical but with a relatively large amount of plume dilution. Even though multiple plumes can mix at these distances downwind, the plumes are so diluted that groundlevel pollutant concentrations are still relatively small. Also, Northwest's facility at Craven Creek is too distant (60 kilometers to the south) to interact with the plumes from the Big Mesa, East and West Dry Basin sites for short-term averages. (However, for annual averages, all sources can and will contribute to the total SO_2 concentrations. This is discussed in more detail under combined impacts.)

The maximum modeled short-term concentrations that occurred in high terrain were generally for stable atmospheric conditions with low wind speeds. This occurred both for concentration estimates based on hypothetical "worst-case" meteorological conditions as well as maximum modeled concentrations with actual off-site meteorological data. Predicted concentrations during unstable conditions and low winds were not as high as impacts under stable conditions but were generally higher than impacts under the more prevalent neutral atmospheric conditions. The highest SO_2 concentrations under unstable conditions invariably occurred at the plant boundaries. This is a typical result for elevated plume impacts in low terrain. The magnitude of the Gaussian vertical dispersion coefficent (sigma z) is much larger for unstable conditions than for neutral conditions. Even though a large sigma z describes rapid dispersion, it also has the effect of causing the elevated plume to reach ground level fairly rapidly without sufficient time for plume dilution to take place.

The maximum short-term impacts from each facility occurred relatively close to each facility. The maximum predicted 3-hour and 24-hour SO_2 concentrations from Exxon's Big Mesa facility occurred about 4 kilometers (2.4 miles) to the west-southwest of the plant, and a little over 2 kilometers (1.2 miles) to the west-southwest of Exxon's West Dry Basin plant. The maximum predicted 3-hour SO_2 concentration from Quasar's East Dry Basin plant occurred about 4 kilometers (2.4 miles) to the southwest of the plant, while the maximum predicted 24-hour SO_2 concentration occurred a little more than 1 kilometer (0.6 miles) to the southeast of the plant. Northwest's maximum predicted 3-hour SO_2 concentration occurred a little more than 2 kilometers (1.2 miles) to the south-southeast of the Craven Creek plant site, and the maximum 24-hour SO_2 concentration was predicted at a distance of a little greater than 2 kilometers (1.2 miles) to the southwest of the plant.

Table 2-8 displays the maximum modeled SO_2 impacts in PSD Class II areas from the individual plant operations. For 24-hour averages, results are presented for both assumed "worst-case" screening conditions and from actual off-site meteorological data. Predicted concentrations above the PSD increments are underscored. Results show that maximum 3-hour and annual averages are below the applicable Class II increments of 512 micrograms/cubic meter and 20 micrograms/cubic meter, respectively. However the Exxon facility at West Dry Basin and the Northwest facility at Craven Creek both exceed the 24-hour SO_2 increment with assumed worst-case meteorology (but not with actual off-site meteorology). American Quasar's facility at East Dry Basin exceeds the 24-hour SO_2 increment with assumed worst-case meteorology, and also on eight different days with actual, off-site hourly meteorology. The maximum concentrations on all eight days occurred on the elevated knoll adjacent and to the southeast of the East Dry Basin plant site.

These results indicate there would not be any significant Class II SO_2 impacts from the facility sited at Big Mesa. Significant SO_2 impacts are not expected from the Exxon facility at West Dry Basin and the Northwest facility at Craven Creek notwithstanding the relatively high concentrations predicted using with assumed worst-case meteorology. Results from actual offsite data are considered more representative because the terrain features where the data were collected (Kemmerer Coal - see Map 1-1) are similar to the terrain features at the Riley Ridge project sites. Furthermore assumed worst case meteorology has somewhat arbitrary assumed values for the persistence of wind direction, wind speed and atmospheric stability. Actual offsite data do not require such persistence assumptions. Significant impacts are expected from the American Quasar 1.2 billion SCFD facility at East Dry Basin. These conclusions will be verified during the WDEQ PSD review. That review should utilize on-site meteorological data.

TABLE 2-8

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN CLASS II AREAS
PROPOSED ACTION

Company	Plant Site	Capacity (Million SCFD)	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)		
			3-hour 512	24-hour[2] 91	Annual 20
Exxon	Big Mesa	600	141	30 (83)	2
Exxon	West Dry Basin	600	278	62 (162)	6
American Quasar	East Dry Basin	1,200	494	124 (299)	14
Northwest Pipeline	Craven Creek	400	159	50 (94)	4

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

The existing Class I areas that were modeled include the Bridger Wilderness, Teton Wilderness, and the Grand Teton National Park. The proposed PSD Class I areas that were modeled include the Scab Creek Primitive Area and Fossil Buttes National Monument. The Fitzpatrick Wilderness and Popo Agie Primitive Area (the latter has been recommended for wilderness designation) are also shown on Map 1-1. However, these two areas were not modeled because they are situated on the east side of the Wind River Range which has peaks over 13,000 feet. It is highly unlikely that the Riley Ridge Project plumes could overcome or advect around such high terrain and impact these two areas.

Tables 2-9 and 2-10 summarize the maximum modeled SO_2 impacts from individual gas treatment plants at existing and proposed PSD Class I areas, respectively. Because of limitations in the application of traditional Gaussian dispersion models at distances beyond 50 kilometers, these results are conservative representations of potential impacts. For 24-hour averages, results are presented for both hypothetical "worst-case" meteorology and actual off-site meteorology. Maximum concentrations in Table 2-9 indicate that individual gas treatment plants in the Proposed Action would comply with all Class I SO_2 increments in all existing Class I areas using both worst-case and actual off-site meteorology.

The maximum concentrations in Table 2-10 indicate that American Quasar's East Dry Basin facilities would exceed the 24-hour Class I increments at the Scab Creek Primitive Area for hypothetical meteorological dispersion conditions but not with actual off-site meteorological data. At Fossil Buttes National Monument maximum SO_2 concentrations are below Class I increments, except for 24-hour averages from Northwest's Craven Creek facility with assumed "worst-case" meteorology. Actual off-site meteorology shows that all predicted concentrations would be below applicable increments.

Based on the results from actual off-site meteorology presented in Tables 2-9 and 2-10, SO_2 emissions from individual gas treatment plants in the Proposed Action would not cause significant SO_2 impacts in any existing or proposed Class I areas. More credance is placed on results with actual meteorological data (albeit off-site) than on results from assumed "worst-case" meteorology.

Table 2-11 summarizes the maximum combined SO_2 impacts in Class II areas. As discussed previously in this subsection, maximum short-term SO_2 impacts in Class II areas from the Proposed Action occur from individual plants and not from combined impacts. However, this is not the case for maximum annual impacts in Class II areas. For annual average impacts in Class II areas, multiple plume trajectories do allow for combined impact from different plants at most receptors. The maximum annual average predicted in Class II areas is 15 micrograms/cubic meter, which was predicted at a distance a little greater than 1 kilometer to the southeast of American Quasar's plant site. This concentration is higher than the maximum annual averages from individual plants. This concentration was predicted at the same receptor where American Quasar's maximum annual average SO_2 impact was predicted.

Table 2-12 displays the maximum combined SO_2 impacts in existing and proposed Class I areas. For combined impacts in Class I areas, the plume

TABLE 2-9

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN EXISTING PSD CLASS I AREAS PROPOSED ACTION

	Maximum SO_2 Concentrations/PSD Increments[1]($\mu g/m^3$)								
	Bridger Wilderness			Teton Wilderness			Teton National Park		
Plant Site	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2	3-Hour 25	24-Hour[2] 5	Annual 2
Big Mesa	3.3	0.7 (1.2)	0.08	1.0	0.2 (0.5)	0.02	0.8	0.2 (0.6)	0.01
West Dry Basin	2.7	0.8 (1.3)	0.05	1.1	0.2 (0.5)	0.02	0.9	0.2 (0.6)	0.01
East Dry Basin	12.4	2.9 (4.7)	0.3	3.9	0.7 (2.0)	0.05	3.4	0.6 (2.3)	0.03
Craven Creek	2.1	0.4 (0.9)	0.05	1.4	0.2 (0.7)	0.02	1.2	0.3 (0.9)	0.02

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-10

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PROPOSED PSD CLASS I AREAS
PROPOSED ACTION

	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)					
	Scab Creek Primitive Area			Fossil Butte National Monument		
Plant Site	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2
Big Mesa	2.2	0.8 (1.3)	0.1	1.8	0.4 (0.7)	0.03
West Dry Basin	2.4	0.8 (1.4)	0.15	2.3	0.5 (1.3)	0.01
East Dry Basin	11.1	4.0 ($\underline{6.1}$)	0.5	8.2	1.7 (4.6)	0.1
Craven Creek	3.4	0.7 (1.5)	0.04	11.7	3.0 ($\underline{6.2}$)	0.12

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-11

COMBINED SO_2 IMPACTS IN PSD CLASS II AREAS

PROPOSED ACTION

Maximum SO_2 Concentrations/PSD Increments (μg/m³)					
3-Hour		24-Hour[1]		Annual	
Concentration	Increment	Concentration	Increment	Concentration	Increment
494	512	124 (299)	91	15	20

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[1] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions. Concentrations underscored are above applicable increments.

TABLE 2-12

COMBINED SO_2 IMPACTS IN EXISTING AND PROPOSED PSD CLASS I AREAS

PROPOSED ACTION

Area	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)		
	3-hour 25	24-hour[2] 5	Annual 2
Bridger Wilderness (existing Class I area)	15.2	4.1 (5.9)	0.4
Teton Wilderness (existing Class I area)	6.2	1.0 (2.9)	0.1
Teton National Park (existing Class I area)	4.9	0.7 (3.3)	0.04
Scab Creek Primitive Area (proposed Class I area)	12.3	4.7 (6.1)	0.7
Fossil Butte National Monument (proposed Class I area)	16.6	3.7 (6.2)	0.3

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] Concentrations in parentheses represent modeling estimates using hypothetical worst-case meteorology.

transport distances are large and individual plumes may grow wide enough to interact at some receptors. Results in Table 2-12 for actual off-site meteorological data show compliance for all time averages. For assumed worst-case meteorological conditions, maximum 24-hour concentrations are above the Class I increment at Bridger Wilderness, Scab Creek Primitive Area, and Fossil Buttes National Monument. However, these latter results are considered conservative because the worst-case conditions assumed are not likely to occur considering the long plume travel time from the sources to the Class I areas. More reasonably representative results are obtained from the actual off-site meteorological data. These results show the combined impacts from all gas treatment plants in the Proposed Action should have no significant SO_2 impact in proposed or existing Class I areas even though 24-hour SO_2 concentrations in the Bridger Wilderness and Scab Creek Primitive Area approach the 5 micrograms/cubic meter Class I increment. These results should be confirmed using on-site meteorological data during the PSD permit review process. As discussed in Table 2-3, footnote 2, impacts to air quality related values (AQRV) could conceivably be significant even if maximum predicted SO_2 concentrations are below applicable PSD increments. Impacts to the AQRV specifically analyzed in this study, i.e., visibility, odor, vegetation (from SO_2 and particulate), and sensitive trout (from acid deposition) are discussed in subsequent subsections.

The locations of the maximum 3-hour, 24-hour, and annual impacts in the Bridger Wilderness are all about 67 kilometers (40.2 miles) to the northeast of the East Dry Basin plant site; in the Teton Wilderness the location of the maximum SO_2 impacts (all time averages) is about 156 kilometers (93.6 miles) to the north of the East Dry Basin plant site; and in Teton National Park the location of the maximum SO_2 impacts (all time averages) is about 139 kilometers (83.4 miles) to the north-northwest of the East Dry Basin plant site. In the Scab Creek proposed Class I area the location of the maximum 3-hour, 24-hour and annual average SO_2 impact is about 62 kilometers (37.2 miles) to the northeast of the East Dry Basin plant site. In the Fossil Butte proposed Class I area, the location of the maximum SO_2 impacts (all time averages) is about 80 kilometers (48 miles) to the southwest of the East Dry Basin plant site.

Map 2-1 shows the locations of the maximum predicted 24-hour SO_2 concentrations in Class II areas and in proposed and existing Class I areas. The locations of maximum 24-hour SO_2 impact (from Table 2-8) from each gas treatment plant are shown in Class II areas. The locations of maximum combined 24-hour SO_2 impact (from Table 2-12) considering all gas treatment plants are shown in proposed and existing Class I areas.

As discussed in the Introduction to this Chapter, total SO_2 burdens should be compared to appropriate NAAQS and WAAQS. In this case the maximum predicted concentrations in all areas are added to the representative background value to determine total ambient SO_2 concentrations. Table 2-13 summarizes the maximum predicted SO_2 concentations in all areas as well as representative background SO_2 concentrations to determine total SO_2 burdens. The total SO_2 concentrations for 3-hour, 24-hour, and annual time averages from actual off-site meteorology are 564 micrograms/cubic meter, 139 micrograms/cubic meter, and 18 micrograms/cubic meter, respectively. These concentrations are well below the applicable 3-hour, 24-hour, and annual SO_2 NAAQS/WAAQS of 1,300, 365, and 80 micrograms/cubic meter, respectively.

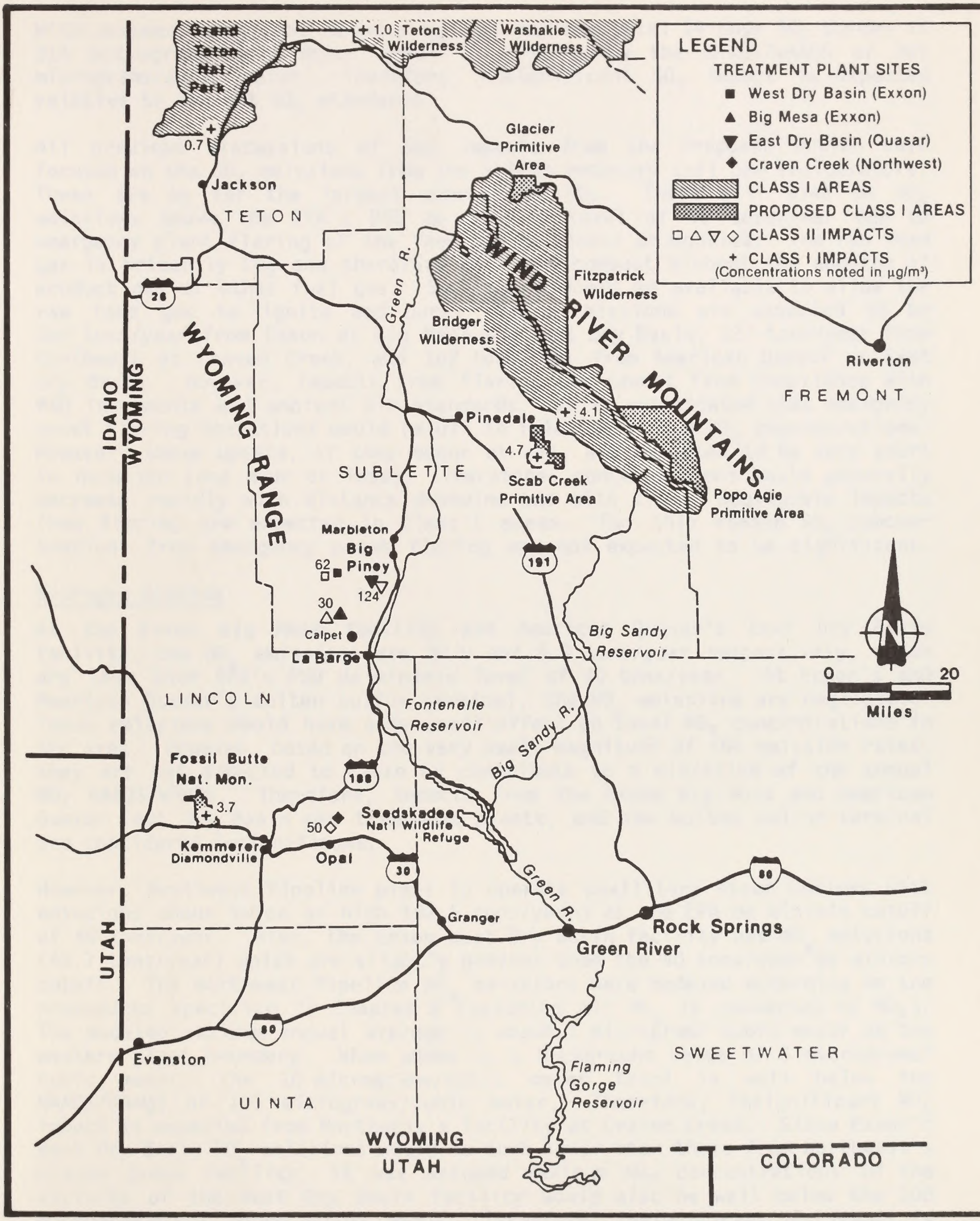
TABLE 2-13

TOTAL MAXIMUM SO_2 IMPACTS

PROPOSED ACTION

Time Period	Maximum Predicted Concentration (μg/m³)	Representative Background Concentration (μg/m³)	Total SO_2 Concentration (μg/m³)	Applicable NAAQS/WAAQS
3-Hour	494	70	564	1,300
24-Hour	124 (299)[1]	15	139 (314)	365
Annual	15	3	18	80

[1] Concentrations in parentheses represent modeling estimates using assumed "worst-case" screening conditions.



MAP 2-1 LOCATIONS OF MAXIMUM 24-HOUR AVERAGE SO_2 CONCENTRATIONS IN PSD CLASS I AND CLASS II AREAS FOR THE PROPOSED ACTION

With assumed worst-case meteorology the maximum total 24-hour SO_2 burden is 314 micrograms/cubic meter which is also below the NAAQS/WAAQS of 365 micrograms/cubic meter. Therefore, insignificant SO_2 impact is expected relative to ambient SO_2 standards.

All previous discussions of SO_2 impacts from the Proposed Action have focused on the SO_2 emissions from the sulfur recovery tail gas incinerators. These are by far the largest sources of SO_2. There will also be SO_2 emissions above the EPA's PSD de minimis level of 40 tons/year due to emergency plant flaring of the feed gas to plants or modules. The raw feed gas is primarily CO_2 and therefore will not combust without the additon of product gas or other fuel gas. Such gases would be available to allow the raw feed gas to ignite and burn. These emissions are expected to be 284 tons/year from Exxon at Big Mesa and West Dry Basin, 127 tons/year from Northwest at Craven Creek, and 162 tons/year from American Quasar at East Dry Basin. However, impacts from flaring are exempt from compliance with PSD increments and ambient air standards. It is anticipated that emergency upset flaring operations would result in relatively high SO_2 concentrations. However, these upsets, if they occur at all, are expected to be very short in duration (one hour or less). Therefore, concentrations would generally decrease rapidly with distance downwind and with time. Negligible impacts from flaring are expected in Class I areas. For this reason SO_2 concentrations from emergency plant flaring are not expected to be significant.

Nitrogen Dioxide

At the Exxon Big Mesa facility and American Quasar's East Dry Basin facility, the NO_x emissions are 28.9 and 5.9 tons/year respectively, which are less than EPA's PSD de minimis level of 40 tons/year. At Exxon's and American Quasar's molten sulfur terminal, the NO_x emissions are negligible. These emissions would have some small effect on total NO_2 concentrations in the area. However, based on the very small magnitude of the emission rates, they are not expected to cause or contribute to a violation of the annual NO_2 NAAQS/WAAQS. Therefore, impacts from the Exxon Big Mesa and American Quasar East Dry Basin gas treatment plants, and the molten sulfur terminal are considered insignificant.

However, Northwest Pipeline plans to operate auxilliary steam boilers with emissions about twice as high (92.5 tons/year) as the EPA de minimis cutoff of 40 tons/year. Also, the Exxon West Dry Basin facility has NO_x emissions (49.7 tons/year) which are slightly greater than the 40 tons/year de minimis cutoff. The Northwest Pipeline NO_x emissions were modeled according to the procedures specified in Chapter 3 (assuming all NO_x is converted to NO_2). The modeled maximum annual average is about 1 microgram/ cubic meter at the eastern plant boundary. When added to a background value of 9 micrograms/ cubic meter, the 10 micrograms/cubic meter total is well below the NAAQS/WAAQS of 100 micrograms/cubic meter. Therefore, insignificant NO_2 impact is expected from Northwest's facility at Craven Creek. Since Exxon's West Dry Basin NO_x emissions would be much lower than those from Northwest's Craven Creek facility, it was assumed maximum NO_2 concentrations in the vicinity of the West Dry Basin facility would also be well below the 100 microgram/cubic meter NAAQS/ WAAQS. Therefore, insignificant NO_2 impact is expected from Exxon's West Dry Basin facility.

Total Suspended Particulate

The gas treatment plants and sulfur terminal would be very small sources of particulates. Emissions from all plants and ancillary facilities are below EPA's de minimis emission rate of 25 tons/year. Therefore, insignificant TSP impact is expected from the Proposed Action.

Carbon Monoxide

The only source of CO above the EPA de minimis emission level of 100 tons/year is the Northwest tail gas incinerator at Craven Creek (6,084 tons/year). These emissions were modeled with techniques described in Chapter 3. The maximum modeled 1-hour and 8-hour concentrations are 406 micrograms/cubic meter and 305 micrograms/cubic meter, respectively. When added to the existing background concentrations, the total concentrations are 3,906 and 1,805 micrograms/cubic meter. These are well below the NAAQS/WAAQS of 40,000 micrograms/cubic meter and 10,000 micrograms/cubic meter, respectively. Therefore, it is concluded that operation of the gas treatment plants in the Proposed Action would not cause significant CO impacts.

Hydrogen Sulfide

The American Quasar gas treatment plant has two sources of H_2S, the CO_2 and nitrogen vents. The Exxon facilities each have one source of H_2S, the venting of the combined CO_2 and nitrogen streams. The Northwest facility has one source of H_2S, the CO_2 vent. At all facilities H_2S emissions are above EPA's de minimis cutoff of 10 tons/year.

Table 2-14 summarizes the maximum modeled H_2S concentrations from the combined interaction of these vents. Predicted concentrations are underscored if they are higher than the WAAQS. The concentrations in the right-hand column of Table 2-14 show that only American Quasar at East Dry Basin would exceed the WAAQS based on actual off-site and hypothetical meteorological data. Impacts from Exxon and Northwest are below the WAAQS based on both actual off-site and assumed worst-case meteorology.

The much higher results predicted by American Quasar result from three factors. First, Quasar's H_2S emissions (170 tons/year) are larger than Exxon's (53 tons/year) or Northwest's (97 tons/year). Second, the Exxon and Northwest plumes are more buoyant than Quasar's because the plume temperature and exit velocities are greater. Third, the proximity of high terrain to the Quasar East Dry Basin site results in higher impacts. The maximum predicted H_2S concentration from the Quasar facility is 237 micrograms/cubic meter at the high terrain about 2 kilometers southeast of the East Dry Basin site.

The maximum concentrations in Table 2-14 for American Quasar indicate potential H_2S compliance problems with the WAAQS. The hourly model predictions were thus reviewed to determine if the standards would be exceeded more frequently than permitted by the WAAQS. It was found that the 40 micrograms/cubic meter would be exceeded more than twice in any five consecutive days and 70 micrograms/cubic meter would be exceeded more than twice per year. Therefore, it is concluded that H_2S emissions from American Quasar's plant at East Dry Basin would result in significant H_2S impacts.

TABLE 2-14

MAXIMUM MODELED H_2S
PROPOSED ACTION

Plant Site	Capacity (Million SCFD)	Company	½-Hour H_2S Concentrations[1]/WAAQS[2] ($\mu g/m^3$)	
			40, 70	40, 70
West Dry Basin	600	Exxon	12	(9)
Big Mesa	600	Exxon	7	(5)
East Dry Basin	1,200	American Quasar	237	(207)
Craven Creek	400	Northwest Pipeline	3	(3)

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[1] These concentrations were evaluated at the plant boundary and beyond because the H_2S WAAQS do not apply within plant property. Concentrations in parentheses are based on hypothetical "worst-case" meteorology. Concentrations for actual off-site meteorology are higher than with "worst-case" assumed meteorology because the "worst-case" assumed meteorology is "F" stability and 2.5 meters/second wind speed (typical assumption by EPA Region VIII and WDEQ, whereas the actual off-site meteorological data contains several hourly occurrences of "F" stability and wind speeds lower than 2.5 meters/second. The lower wind speed results in less plume dilution and consequently higher ½-hour H_2S concentrations.

[2] The WAAQS are shown immediately beneath the column heading. Concentrations underscored exceed one or both of the WAAQS. The 40 micrograms/cubic meter-limit is not to be exceeded more than twice in any five consecutive days and the 70 micrograms/cubic meter limit is not to be exceeded more than twice in any year.

Some concern has been expressed regarding the photochemical fate of COS. According to Logan et al. (1979), the oxidation of COS is probably initiated by reaction with the OH radical. Subsequent reactions of intermediate products ultimately form SO_2. The rates of the various reactions are not well known at this time, however, an estimate of the global mean lifetime for COS is 200 days (Logan et al. 1979). Since this lifetime is very long, emissions of COS are not expected to significantly affect total SO_2 burdens in the area. Other than SO_2, no known toxic species are produced by the photochemical oxidation of COS. Therefore, insignificant impacts are expected from secondary pollutants formed in the atmosphere from the COS emissions.

Carbon Dioxide

The gas treatment plants will release relatively large quantities of CO_2 to the atmosphere (1.87 billion cubic feet/day) unless the CO_2 is purified and sold. Venting the CO_2 will not significantly increase the atmospheric loading of that species in the total Sublette Air Basin. It is not anticipated that the Riley Ridge CO_2 emissions above will cause any noticeable increase in average atmospheric temperatures due to the "greenhouse effect", although considerable uncertainity exists on a global scale whether increased atmospheric burdens of CO_2 result in climatic warming trends. The CO_2 in the CO_2 and nitrogen vents was also modeled to determine if annual averages in the workplace could exceed the ACGIH 5,000 parts/million threshold limit value. (For the average barometric pressure and temperature at the plant sites, 5,000 parts/million of CO_2 is equivalent to approximately 11 grams/cubic meter).

Table 2-16 summarizes the maximum modeled CO_2 impacts from the nitrogen and CO_2 vents. The CO_2 impacts are well below the 11 grams/cubic meter significance level for all sources. Therefore, the CO_2 and N_2 vents are not expected to result in significant CO_2 impacts.

Helium

Helium would be vented from all gas treatment plants if it is not purified and sold. However, as discussed in detail in Chapter 3, ground level He concentrations, in the workplaces of all treatment plants, are expected to be well below the 30,000 parts/million required to cause asphyxiation. Therefore, no significant He impacts are expected.

ACID DEPOSITION IN CLASS I AREAS

This section addresses concerns about the potential acidification of sensitive high mountain lakes in the Bridger Wilderness caused by SO_2 and NO_x emissions from the Riley Ridge Project. The greatest potential for acute acidification occurs during the spring and summer runoff of the accumulated snowpack. Acidic compounds which are deposited or which form in the snowpack during the winter time period will be released over the 2-3 month snowpack runoff period, and may cause "acid shock" to streams and lakes in the area.

The high mountain streams and lakes in the Bridger Wilderness are known to be inhabited by various species of trout (golden, rainbow, brook, and cutthroat), as well as other fish. Substantial reduction of pH in these

TABLE 2-16

MAXIMUM MODELED CO_2 CONCENTRATIONS
PROPOSED ACTION

Plant Site	Capacity (Million SCFD)	Company	Annual Average CO_2 Concentrations[1]/TLV[2] (g/m^3)
			11
West Dry Basin	600	Exxon	0.02
Big Mesa	600	Exxon	0.01
East Dry Basin	1,200	American Quasar	0.5
Craven Creek	400	Northwest Pipeline	0.004

[1] The maximum impact from these plumes occur in high terrain (not in the workplace).

[2] TLV represents the ACGIH threshold limit value. Its value is shown immediately beneath the column heading.

waters could adversely impact the fish habitat and spawning grounds. Many of these streams and lakes are believed to have little capacity for neutralization of acidic runoff and may therefore be extremely sensitive to acid deposition increases. High mountain streams and lakes in other Class I areas such as the Teton Wilderness and Teton National Park, also contain various trout species which are susceptible to changes in lake pH. However, for reasons discussed in detail in Chapter 3, these other Class I areas are expected to undergo smaller pH changes than are anticipated in the Bridger Wilderness. Coherent plumes are not expected to surmount the mountains of the Wind River Range because of the very large elevation differential (over 5,000 feet) between the mountain tops and plume heights. Surmounting such a large elevation differential and the potential energy associated with it during stable conditions would require the coherent plumes and the lower level air mass they are in to have a greater amount of kinetic energy. The wind speeds associated with such kinetic energies are expected to be so great as to not be observed normally in the study area. While it may be possible (albeit unlikely) that Riley Ridge pollutants in neutral or unstable air masses (e.g., in thunderstorm undrafts) might surmount the Wind River Range, the degree of dilution and dispersion under such conditions is so great that resultant concentrations of acid species are expected to be negligible in the Fitzpatrick Wilderness and Popo Agie Primitive Areas. Therefore, insignificant impact from acid deposition is expected in these two areas.

Three lakes in the Bridger Wilderness that would likely experience the largest pH changes were selected by U.S. Forest Service personnel (1982) for baseline water quality sampling during the Riley Ridge EIS scoping process. They are Clear Lake (north), Hobbs Lake and Clear Lake (south). These lakes are at relatively high elevations (9,000 to 11,000 feet), have substrates derived from granitic materials, and are primarily recharged by snowmelt. Table 2-17 summarizes the baseline pH and alkalinity in the three lakes as measured by ERT in late August 1982. The pH of the lakes is slightly less than neutral and the capability of the lakes to resist the effects of acid input is small based on the low buffering capacity (alkalinity values of 85 to 112 microequivalents/liter). These lakes also are known to support populations of game fish (Wyoming Game and Fish Department 1980).

The procedures used to calculate acid deposition to the lakes from Riley Ridge Project emissions and resulting water chemistry changes in these three lakes are presented in Chapter 3. Note that the calculated alkalinity values in Table 2-17 were used in the modeling assessment, and not the higher measured alkalinity values. For each lake studied, a range of results is given. The largest calculated pH changes assume there is no neutralization of acid species in the snowpack and there is no neutralization of acid species in the snowmelt during runoff to the lakes (100 percent input). The smallest calculated pH changes assume that 50 percent of the total possible H+ input to the lakes never reaches the lakes because of neutralization by alkaline species in the snowpack and in the soil during runoff. The 50 percent value represents the mid-range of possible values, while the 100 percent value represents the worst-case acid input.

Changes in stream pH have not been explicitly modeled in this assessment due primarily to a lack of adequate data, i.e., discharge rate. Changes in pH

TABLE 2-17

ESTIMATED EFFECTS ON WATER CHEMISTRY OF THREE LAKES IN THE BRIDGER WILDERNESS

PROPOSED ACTION

	Clear Lake (North)	Hobbs Lake	Clear Lake (South)
Baseline pH[1]	6.60	6.50	6.45
Measured Alkalinity[1] (eq/l x 10^{-6})	110.0	112.0	85.0
Calculated Alkalinity (eq/l x 10^{-6})	19.95	15.85	14.13
Incremental H^+ Input (eq/l x 10^{-6})	0.23 - 0.45	0.59 - 1.17	2.01 - 4.02
Remaining Alkalinity (eq/l x 10^{-6})	19.72 - 19.50	15.26 - 14.68	12.12 - 10.11
Resulting pH	6.59 - 6.59	6.48 - 6.47	6.38 - 6.30
ΔpH	0.01	0.02 - 0.03	0.07 - 0.15
After accounting for the potential effect of the freezing point depression of acidic snow:			
Resulting pH	6.55 - 6.55	6.48 - 6.47	6.38 - 6.30
ΔpH	0.05	0.02 - 0.03	0.07 - 0.15
After accounting for the potential effect of plant flaring:			
Resulting pH	6.55 - 6.55	6.48 - 6.47	6.36 - 6.28
ΔpH	0.05	0.02 - 0.03	0.09 - 0.17

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[1] Measurements taken by ERT in August 1982.

in streams immediately below the lakes should approximate the changes in the lakes above them. For streams feeding the lakes, insufficient data exists to adequately assess pH changes. Data collection recommendations for streams and lakes are presented later in this section.

Short-Term Effects

Potential short-term changes in water chemistry resulting from the Proposed Action are presented in Table 2-17 for the three lakes in the Bridger Wilderness. The maximum incremental pH change is predicted to occur at Clear Lake (south). Potential pH decreases at Clear Lake (south) range from 0.09-0.17 pH resulting in new pH levels of 6.36 to 6.28. Clear Lake (south) would probably experience the largest pH change because it has the lowest baseline pH and because it is predicted to experience the greatest hydrogen ion deposition (primarily attributable to a high frequency of winds to the lake from the gas treatment plant sites). New pH levels at Hobbs Lake and Clear Lake (north) are predicted to be 6.48 to 6.47, and 6.55, respectively.

For the Proposed Action the resultant pH for all lakes is not expected to drop below 6.28. This should be well within the tolerance level of known fish species in the Bridger Wilderness as defined by the significance criteria presented earlier. Therefore, no significant impact to fish populations or their habitat is anticipated as a result of these pH levels.

The modeling results presented above are based on the assumption that as the lakes are totally mixed with snowmelt only the carbonate system's contribution to alkalinity buffers the incoming H^+. The source of the calculated alkalinity values is inorganic carbon species in the lake in equilibrium with CO_2. Based on the fact that the measured alkalinity values are higher, there are possibly some organic carbon species available to buffer H^+ also. However, since the chemical nature of these species is not known, their buffering "effectiveness" is unknown and therefore not accounted for in the modeling.

Past studies (e.g., Seip 1980; Foster 1978; Overrein et al 1980) have shown that acid concentrations are highest during early stages of snowpack runoff. This has been attributed to the freezing point depression of acidic snow. The freezing point depression refers to the lowering of the freezing point of water to below 0°C due to the presence of soluble impurities such as H+. Thus, that portion of the snowpack containing H+ will tend to melt prior to purer snowpack. This provides the snowpack with a network of veins so that soluble impurities may drain out. The acidic material thus concentrates in the early stages of the runoff. Various laboratory and field experiments summarized by Seip (1980) indicate that 50-80 percent of the pollutants are released when the first 30 percent of the snow melts. Seip states, "The very first meltwater may have concentrations about 5 times the values found in bulk snow; in extreme cases the factors may perhaps reach 10."

The potential effect on lake pH due to the freezing point depression is affected by the lake recharge time, that is the time required for the lakes to totally mix with the runoff. Table 2-18 is a comparison of lake volume to snowpack water equivalent volume. Clear Lake (north) which ultimately drains a much larger watershed, is calculated to recharge in the shortest time, about every two weeks; Hobbs Lake and Clear Lake (south) could take up to six or seven weeks to totally recharge.

TABLE 2-18

ESTIMATED LAKE RECHARGE TIMES

	Lake Volume (acre-ft)	Snowpack Volume (acre-ft)	Recharge Time[1] (days)
Clear Lake (North)	2,740	14,461	14
Hobbs Lake	700	1,256	42
Clear Lake (South)	900	1,350	50

[1] Assume total runoff lasts 75 days.

For Hobbs Lake and Clear Lake (south), the long recharge period suggests the freezing point depression will not be a significant factor, the early snowmelt at these two lakes cannot totally recharge the lake, and the increased acidic input will be diluted accordingly. Only at Clear Lake (north) is the recharge rate short enough to allow the freezing point depression to be a potential factor. Assuming the early runoff at Clear Lake (north) has a factor of five higher acid concentration (a factor of 10 is considered overly conservative based on the quotation noted above), the resulting pH would be 6.55 or a net decrease of 0.05 (compared to a pH of 6.59 or a net decrease of 0.01 pH units in Table 2-17). This level is well within the tolerance of fish species in these lakes as defined by the significance criterion (pH of 6.0). As discussed in the significance criteria section, the selection of pH 6.0 is based on field data summarized by Haines and Schofield (1980) and reflects the pH at which reproductive failure can occur. Therefore insignificant short-term acid deposition impact is expected after accounting for the freezing point depression of acidic snow.

While significant impacts to fish populations are not expected due directly to the predicted pH changes, the loss of fish populations is likely one of the last aquatic biological effects of acidification. In the ultra-oligotrophic waters of the Bridger Wilderness, vegetative species diversity may decline as the pH decreases. However, productivity may remain unaffected. Given the lack of data regarding the types of vegetative species in high altitude Bridger Wilderness lakes as well as how the vegetative species could be impacted as pH declines, or how changes in vegetation could affect habitat quality for other food organics it is unknown whether significant impacts to aquatic vegetation could occur for the pH changes predicted in this assessment.

Potential acid deposition impacts from plant upset conditions, such as flaring, have also been accounted for. Flaring can produce large quantities of SO_2 for short time periods. When flaring emissions from all facilities are included (assuming they could all occur during the same year), the resulting pH levels at the worst-case lake (Clear Lake South) change from a baseline of 6.45 to 6.28. This decrease in resulting pH is not large enough to result in any significant impacts to lake fish populations or habitat.

Long Term Effects

The long-term effects of acid deposition in the Bridger Wilderness cannot be estimated at this time with high confidence. On a short-term basis, the acidic input to sensitive lakes in the area from the Riley Ridge Project is small enough to be neutralized by the existing inorganic and bicarbonate alkalinity levels. This is only a portion of the measured baseline total lake alkalinity. Clearly, organic alkaline species are also available for buffering. On a long-term basis (the life of the gas treatment plants), the amount the H^+ from wet and dry deposition will obviously be greater than for short-term deposition but the ecosystem might also have ample time to replace some of the inorganic alkalinity needed to neutralize H^+. For example, the weathering of rocks might cause some replacement. However, it is unknown whether the ecosystem can replace alkalinity at a rate equal to the alkalinity lost from buffering the H+.

VISIBILITY IMPAIRMENT IN PSD CLASS I AREAS

The Proposed Action includes gas treatment plants at West Dry Basin, Big Mesa, East Dry Basin, and Craven Creek. Emissions from these facilities were modeled to determine if visibility impairment could occur in the proposed and existing PSD Class I areas. Worst-case visibility impairment would occur at the nearest Class I areas to the Riley Ridge Project. The closest existing Class I area is the Bridger Wilderness, 69 kilometers northeast of East Dry Basin. The two closest proposed Class I areas are the Scab Creek Primitive Area (61 kilometers northeast of East Dry Basin) and Fossil Buttes National Monument (39 kilometers west of Craven Creek and 65 kilometers southwest of Big Mesa). Three separate visibility impairment scenarios were modeled based on the proximity of the nearest proposed and existing Class I areas to the Riley Ridge Project using conservative EPA screening procedures (see Chapter 3):

- Case 1 evaluated the potential impact of the Riley Ridge Project on the visibility in Bridger Wilderness.
- Case 2 examined the visibility impacts at the Scab Creek Primitive Area.
- Case 3 analyzed the impact at Fossil Buttes National Monument.

The analysis included all known project emissions of SO_2, NO_x, and particulates except emergency generators, flares, and diesel-fired well drilling. The excluded sources are all temporary or construction-related, and therefore exempt from demonstrating no visibility impairment in Class I areas. (See the significance criteria discussion in the Introduction to this Chapter.)

For Cases 1 and 2, all the sources were colocated at East Dry Basin. For Case 3, Northwest's emissions were located at Craven Creek and all other emissions were assumed to originate from Big Mesa. The optical depths were calculated for each source, and added together for use in the contrast equations.

The results for these three cases show that all the physical parameters contrast degradation, changes in coloration, and visual range reduction are less than the significance criteria of 0.1. Therefore, for the Proposed Action, significant visibility impairment is not likely to occur at the Bridger Wilderness, Scab Creek Primitive Area, or Fossil Buttes National Monument. From these results it can also be concluded that the other Class I areas, i.e., the Teton Wilderness and Teton National Park, would not have significant visibility impairment from the Proposed Action.

IMPACTS TO VEGETATION AND SOILS IN PSD CLASS I AREAS

Because maximum predicted SO_2 concentrations are below applicable PSD Class I increments in all proposed and existing Class I areas, SO_2 impacts sensitive vegetative species, i.e., lichens, are expected to be insignificant. As discussed in more detail in the significance criteria sections, particulate emissions are not expected to result in significant impact to sensitive vegetation either.

SECONDARY GROWTH IMPACTS

The population increases which would be expected in southwestern Wyoming due to the Riley Ridge Project are summarized in Table 2-19.

The largest local population increases for each of the three alternatives would occur in the Kemmerer-Diamondville area in 1986. For the Proposed Action, these two communities would experience a projected population increase of about 3,500 people. The air quality impacts of such a population increase would be due primarily to residential space heating, refuse burning, and vehicular exhaust. For the purposes of this analysis, it was assumed that atmospheric emissions due to residential space heating would result from natural gas and wood combustion.

The results of the modeling are shown in Table 2-20 which include representative background concentrations for each pollutant and averaging time. The results show that maximum pollutant burdens in the Kemmerer-Diamondville area will not exceed appropriate NAAQS/WAAQS. Therefore, pollutant concentrations from secondary growth are insignificant. Though concentrations were calculated only for the Kemmerer-Diamondville area in 1986, the results for other communities and during other years would be even less significant since the population increases would be less.

CUMULATIVE IMPACTS

As noted in the Chapter 1, SO_2 emissions from the Whitney Canyon Gas Treatment Plant and Carter Creek Gas Treatment Plant (see Map 4-1) have not been accounted for in the measured baseline air quality. This is because the facilities have come online after the dates associated with the measured air quality data used in this study to determine baseline air quality. Based on the very low magnitude of the SO_2 emissions from the Carter Creek facility (about 34 pounds/hour) and its large distance from the nearest Riley Ridge gas treatment plant site (Northwest's Craven Creek plant at about 60 kilometers), it is not expected that the Carter Creek SO_2 emissions would result in significant cumulative impacts with the Riley Ridge gas treatment plants. However, the Whitney Canyon gas treatment plant is a relatively large source of SO_2 (about 3,117 pounds/hour) but is also relatively far from the nearest Riley Ridge gas treatment plant site (Northwest's Craven Creek plant at about 65 kilometers). While cumulative SO_2 impacts of the Whitney Canyon emissions with the Craven Creek emissions are not expected for 3-hour and 24-hour time periods, due to this large distance, annual average cumulative impacts could be expected. However, these annual average cumulative concentrations will probably not exceed about 5 micrograms/cubic meter of SO_2 based on the individual plant impacts of Craven Creek modeled in this study and the predicted Whitney Canyon SO_2 impacts in the PSD permit on file with the Wyoming Department of Environmental Quality. The 5 micrograms/cubic meter maximum cumulative concentration is 25 percent of the applicable Class II PSD increment of 20 micrograms/cubic meter. Therefore, insignificant cumulative SO_2 impact is expected from the Whitney Canyon and Northwest's Craven Creek gas treatment plants. Because the other Riley Ridge gas treatment plants are even further away from the Whitney Canyon plant, insignificant cumulative SO_2 impacts are expected with them as well.

TABLE 2-19

MAXIMUM ESTIMATED POPULATION INCREASE FROM RILEY RIDGE PROJECT PROPOSED ACTION

County	Community	Population Increase[1]	Year
Lincoln	Afton	20	1986
	Cokeville	62	1986
	Diamondville	1,267	1986
	Kemmerer	2,228	1986
	LaBarge	1,206	1985
	Thayne	6	1985
Sublette	Big Piney	836	1985
	Marbleton	771	1985
	Pinedale	160	1985
Sweetwater	Granger	118	1986
	Green River	555	1986
	Rock Springs	454	1986
	South Superior	33	1986
	Wamsutter	15	1985

Source: Western Research Corporation; Laramie, Wyoming (1982)

[1] Based on County Level Economic Analysis

TABLE 2-20

AIR QUALITY IMPACT OF SECONDARY GROWTH ON THE KEMMERER-DIAMONDVILLE AREA

PROPOSED ACTION

	Total Maximum Concentrations/NAAQS/WAAQS ($\mu g/m^3$)									
	1-Hour		3-Hour		8-Hour		24-Hour		Annual	
Pollutant	Conc.	Std	Conc	Std	Conc	Std	Conc	Std	Conc	Std
TSP	--	--	--	--	--	--	62.4[5]	150	30.6[7]	60
SO_2	--	--	70.4[2]	1,300	--	--	15.1[6]	365	3.03[8]	80
NO_x	--	--	--	--	--	--	--	--	9.3[9]	100
CO	3,623[1]	40,000	--	--	1,593[4]	10,000	--	--	--	--
HC	--	--	8.3[3]	160	--	--	--	--	--	--

[1] Includes a background concentration of 3,500 micrograms/cubic meter.

[2] Includes a background concentration of 70 micrograms/cubic meter.

[3] Does not include a background concentration. Background is unknown but probably very low.

[4] Includes a background concentration of 1,500 micrograms/cubic meter.

[5] Includes a background concentration of 60 micrograms/cubic meter.

[6] Includes a background concentration of 15 micrograms/cubic meter.

[7] Includes a background concentration of 30 micrograms/cubic meter.

[8] Includes a background concentration of 3 micrograms/cubic meter.

[9] Includes a background concentration of 9 micrograms/cubic meter.

AIR QUALITY RELATED VALUES IMPACTS

As noted in the significance criteria subsection, the Forest Service has identified eight AQRV that include: flora, fauna, water, odor, soil, visibility, cultural/archeological, and geologic. For a number of reasons impact analyses cannot be performed at the present time on all AQRV. However, impacts to some of these AQRV have been analyzed in this study and determined to be insignificant according to the identified significance criteria. As discussed in previous subsections these include insignificant impacts to odor, visibility, flora (due directly from SO_2 and particulate) and acid deposition effects on trout in sensitive high altitude lakes (due directly from lake pH changes).

SUMMARY OF THE PROPOSED ACTION OPERATIONS-RELATED IMPACTS

Operation of the Proposed Action is expected to result in insignificant air quality impacts except for the following:

1) Twenty-four hour SO_2 concentrations from the American Quasar facility exceed the 91 microgram/cubic meter PSD Class II increment more than allowed (i.e., more than once per year). The maximum modeled concentrations are 124 and 299 micrograms/cubic meter using actual, off-site meteorological data and assumed, "worst-case" assumptions, respectively. While the 3-hour SO_2 PSD increment is not predicted to be exceeded (and therefore the impact is insignificant), the maximum predicted 3-hour average from Quasar's East Dry Basin facility is 96 percent of the 3-hour Class II increment.

2) Half-hour H_2S concentrations at plant boundaries from the American Quasar facility at East Dry Basin exceed the Wyoming one-half hour H_2S standards of 40 and 70 micrograms/cubic meter more than allowed, i.e, more than twice in any 5 days and more than twice per year, respectively. The maximum one-half hour H_2S concentrations for each gas treatment plant using actual, off-site meteorological data (and assumed worst-case meteorology) are: 237 (207) micrograms/cubic meter. The area where these significant H_2S impacts are predicted is the high terrain about 2 kilometers (1.2 miles) to the southeast of Quasar's East Dry Basin site.

3) Odor impacts of H_2S are expected to be significant in localized high terrain areas around the Exxon West Dry Basin and Big Mesa plants as well as around Quasar's East Dry Basin plant because the maximum predicted concentrations from these facilities are 12, 7, and 237 micrograms/cubic meter, respectively, which exceed the 6.5 micrograms/cubic meter ordor threshold.

IMPACTS OF THE BUCKHORN ALTERNATIVE

The Buckhorn Alternative plant siting is summarized as follows: American Quasar would operate a 1.2-billion SCFD gas treatment facility at the Buckhorn site; Exxon would operate two 600-million SCFD facilities, one at West Dry Basin and one at East Dry Basin; and Northwest Pipeline would operate a single 400-million SCFD plant at the Craven Creek site. Refer to Map 1-1 (map pocket) for the site locations.

PROPOSED WELL DRILLING OPERATIONS

The Buckhorn Alternative does not affect the air quality impacts of the proposed well drilling operations. Therefore, the impacts of this alternative would be identical to those described in the Proposed Action. No significant impacts are expected.

GAS TREATMENT PLANT CONSTRUCTION

Table 2-21 presents the predicted TSP concentrations from individual construction activities at the gas treatment plant sites. All concentrations are below the 60 micrograms/cubic meter NAAQS/WAAQS and are therefore insignificant. The maximum impact of 47 micrograms/cubic meter occurs at the proposed Northwest plant site at Craven Creek.

For reasons discussed in detail under the Proposed Action, combined impacts from concurrent, but spatially separated construction sources are not expected to be significantly greater than TSP impacts from individual construction activities. Therefore, insignificant TSP impacts are also expected when considering the combined effects of all sources.

Fugitive dust from the construction activities would result in localized visibility reduction. However, because the activities are temporary and most of the dust would settle out quickly, no significant impacts are expected.

OPERATION OF THE WELL FIELD

Normal emissions during well field operations are well below the EPA de minimis emission levels and, therefore, insignificant impacts are expected. Upset conditions could result in flaring of well field gas, likely resulting in SO_2 concentrations exceeding the 3-hour NAAQS/WAAQS of 1,300 micrograms/cubic meter if poor atmospheric dispersion exists. However, as discussed in the Proposed Action, the probability of flaring occurring during poor dispersion conditions has been calculated to be less than 1:100,000 for Exxon and about 3:10,000 for Northwest. Therefore, no significant impact is expected.

OPERATION OF THE GAS TREATMENT PLANTS

Sulfur Dioxide

Similar to the Proposed Action, maximum short-term SO_2 impacts in Class II areas from the Buckhorn Alternative would result from single plant impacts and not from the interaction of multiple plumes from different plants. Therefore, the short-term Class II SO_2 impacts presented in the Proposed Action for the Exxon facility at West Dry Basin and the Northwest facility at Craven Creek also apply to the Buckhorn Alternative. The Exxon facility at East Dry Basin and the American Quasar facility at Buckhorn were modeled to determine their maximum Class II SO_2 impacts. Table 2-22 displays the maximum modeled SO_2 impacts in PSD Class II areas from the individual plant operations. For 24-hour averages, results are presented for both assumed "worst-case" screening conditions and from actual off-site meteorological data. The maximum impacts at Buckhorn from American Quasar's facility occurred in low terrain from unstable atmospheric conditions. The maximum impacts from Exxon's facility at East Dry Basin occurred in high terrain

TABLE 2-21

MAXIMUM MODELED TSP CONCENTRATIONS FROM CONSTRUCTION OF BUCKHORN ALTERNATIVE[1]

Plant Site/Company	Annual Average Concentration (μg/m^3) Modeled	Background	Total	NAAQS/WAAQS
West Dry Basin/Exxon	10	30	40	60
East Dry Basin/Exxon	10	30	40	60
Buckhorn/Am Quasar	13	30	43	60
Craven Creek/Northwest	17	30	47	60
Sulfur Loadout	2	30	32	60

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[1] Impacts from concurrent construction activities at other sites are expected to add (at most) 1 microgram/cubic meter to these concentrations. This results in a maximum predicted impact of 48 micrograms/cubic meter at Craven Creek, below the 60 microgram/cubic meter NAAQS/WAAQS.

TABLE 2-22

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PSD CLASS II AREAS
BUCKHORN ALTERNATIVE

Company	Plant Site	Capacity (Million SCFD)	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)		
			3-hour 512	24-hour[2] 91	Annual 20
Exxon	East Dry Basin	600	130	33 (79)	4
Exxon	West Dry Basin	600	278	62 ($\underline{162}$)	6
American Quasar	Buckhorn	1,200	37	14 ($\underline{97}$)	7
Northwest Pipeline	Craven Creek	400	159	50 ($\underline{94}$)	4

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

under stable conditions. Although maximum concentrations under hypothetical "worst-case" meteorology indicate significant 24-hour SO_2 impacts for the West Dry Basin, Buckhorn, and Craven Creek facilities, maximum modeled impacts with actual, off-site meteorological data are below the PSD Class II increment of 91 micrograms/ cubic meter. Maximum modeled 3-hour and annual impacts are also below appropriate PSD increments.

The maximum predicted 3-hour SO_2 concentrations from Exxon's East Dry Basin facility occurred about 4 kilometers in high terrain to the southwest of the plant. The maximum 24-hour SO_2 was predicted a little more than 1 kilometer to the southeast of Exxon's plant in high terrain. The maximum predicted 3-hour average SO_2 concentration from the Buckhorn plant occurred about 24 kilometers to the west of the Buckhorn site in high terrain. The maximum 24-hour average was predicted to occur at a distance a little greater than 11 kilometers to the west-southwest of the plant. The locations of the maximum predicted 3-hour and 24-hour SO_2 concentrations for Northwest's Craven Creek plant and Exxon's West Dry Basin plant are the same as described in the Proposed Action.

Tables 2-23 and 2-24 summarize maximum predicted impacts in existing and proposed Class I areas from individual gas treatment plants, respectively. Predicted concentrations above the Class I SO_2 increments are underscored. Results show that actual, off-site meteorological data predict all individual facilities in the Buckhorn Alternative will comply with Class I increments. However, assumed "worst-case" meteorology indicates there may be compliance difficulties with the facilities at Buckhorn and Craven Creek.

Based on results presented in Tables 2-22 through 2-24, it is expected that the individual facilities comprising the Buckhorn Alternative would not have significant SO_2 impact in Class I and II areas (notwithstanding the predicted high concentrations from hypothetical, worst-case meteorology). However, these conclusions should be verified during the PSD review process using on-site data.

Table 2-25 summarizes the maximum combined SO_2 impacts in Class II areas. Similar to the Proposed Action, combined impacts for annual averages in Class II areas are higher than maximum impacts from individual facilities. The maximum combined SO_2 annual average impact in Class II areas is 7.8 micrograms/cubic meter at a distance of a little more than 15 kilometers to the west of Buckhorn site. This is below the Class II increment of 20 micrograms/cubic meter.

Table 2-26 summarizes the maximum combined SO_2 impacts in Class I areas. For the Buckhorn Alternative, the locations of the maximum 3-hour, 24-hour, and annual SO_2 impacts in all proposed and existing Class I areas are the same as those described in the Proposed Action. The results show that for actual off-site meteorology, maximum combined SO_2 impacts in all existing and proposed Class I areas would be below 3-hour, 24-hour, and annual PSD Class I increments of 25, 5, and 2 micrograms/cubic meter except the maximum 24-hour average at the Scab Creek Primitive Area. However, the highest second-highest 24-hour SO_2 concentration (used to determine compliance with PSD increments) at Scab Creek based on actual off-site meteorology is 4.3 micrograms/ cubic meter. The highest 24-hour average SO_2 concentrations at Bridger, Scab Creek, and Fossil Buttes exceed the 5 micrograms/cubic meter

TABLE 2-23

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN EXISTING PSD CLASS I AREAS BUCKHORN ALTERNATIVE

	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)								
	Bridger Wilderness			Teton Wilderness			Teton National Park		
Plant Site	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2	3-Hour 25	24-Hour[2] 5	Annual 2
East Dry Basin	3.3	0.8 (1.2)	0.06	1.0	0.2 (0.5)	0.02	0.9	0.2 (0.6)	0.01
West Dry Basin	2.7	0.8 (1.3)	0.05	1.1	0.2 (0.5)	0.02	0.9	0.2 (0.6)	0.01
Buckhorn	14.6	3.0 (6.8)	0.28	3.7	0.6 (2.0)	0.07	3.1	0.6 (2.1)	0.05
Craven Creek	2.1	0.4 (0.9)	0.05	1.4	0.2 (0.7)	0.02	1.2	0.3 (0.9)	0.02

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-24

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PROPOSED PSD CLASS I AREAS
BUCKHORN ALTERNATIVE

	Maximum SO_2 Concentrations/PSD Increments[1] (μg/m^3)					
	Scab Creek Primitive Area			Fossil Butte National Monument		
Plant Site	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2
East Dry Basin	2.8	1.1 (1.6)	0.07	2.2	0.4 (1.2)	0.04
West Dry Basin	2.4	0.8 (1.4)	0.15	2.3	0.5 (1.3)	0.01
Buckhorn	16.8	4.3 (8.2)	0.37	7.6	1.4 (4.0)	0.14
Craven Creek	3.4	0.7 (1.5)	0.04	11.7	3.0 (6.2)	0.12

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-25

COMBINED SO_2 IMPACTS IN PSD CLASS II AREAS
BUCKHORN ALTERNATIVE

Maximum SO_2 Concentrations/PSD Increments (μg/m³)					
3-Hour		24-Hour[1]		Annual	
Concentration	Increment	Concentration	Increment	Concentration	Increment
278	512	62 (162)	91	7.8	20

[1] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions. Underscored concentrations are above applicable increments.

TABLE 2-26

COMBINED SO_2 IMPACTS IN EXISTING AND PROPOSED PSD CLASS I AREAS BUCKHORN ALTERNATIVE

Area	Maximum SO_2 Concentrations/PSD Increments[1] (μg/m³) 3-hour 25	24-hour[2] 5	Annual 2
Bridger Wilderness (existing Class I area)	19.0	4.8 (7.6)	0.5
Teton Wilderness (existing Class I area)	6.5	1.0 (3.3)	0.1
Teton National Park (existing Class I area)	5.0	1.0 (3.7)	0.05
Scab Creek (proposed Class I area)	19.5	5.9[3](9.4)	0.70
Fossil Butte National Monument (proposed Class I area)	13.5	3.6 (6.2)	0.2

---

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

[3] The listed value represents the maximum predicted concentration. The highest second highest value (used for determination of compliance with PSD increments) is 4.3 micrograms/cubic meter, which is less than the 5 microgram/cubic meter PSD limit.

increment with assumed, worst-case meteorology. However, because more credance is placed on results from actual off-site meteorology versus assumed worst-case meteorology, it is concluded that combined SO_2 impacts for the Buckhorn alternative would not result in significant impacts in Class I and Class II areas.

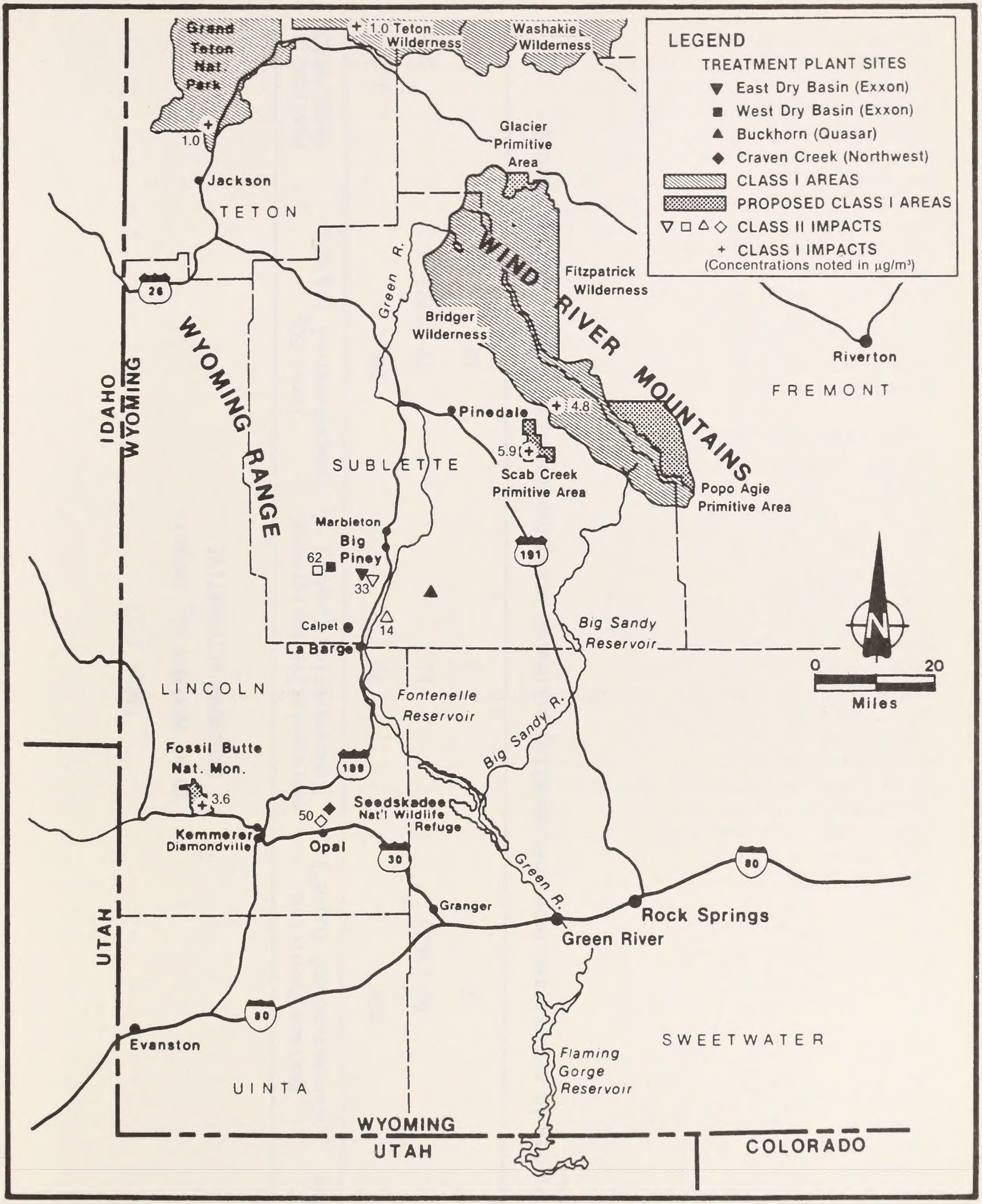
The locations of the predicted maximum 24-hour SO_2 impacts (from Table 2-22) in Class II areas, and in the proposed and existing Class I areas (from Table 2-26) are presented in Map 2-2. Since 24-hour average impacts are usually more limiting than 3-hour and annual impacts, the locations of the maximum 24-hour impacts are helpful in illustrating the extent of the SO_2 impacts.

Like the Proposed Action, total atmospheric burdens of SO_2 due to the operation of the plants in the Buckhorn Alternative would not cause any violations of the 3-hour, 24-hour, and annual NAAQS/WAAQS. When combined with representative 3-hour, 24-hour, and annual background SO_2 concentrations of 70, 15, and 3 micrograms/cubic meter, respectively, the maximum concentrations with actual, off-site meteorology are: 348 micrograms/cubic meter 3-hour average, 77 micrograms/cubic meter 24-hour average, and 10 micrograms/cubic meter annual average. With assumed worst-case meteorology, the maximum 24-hour total SO_2 burden is 177 micrograms/cubic meter. As summarized in Table 2-27, all concentrations are well below the respective SO_2 standards of 1,300, 365, and 80 micrograms/cubic meter; therefore, insignificant impact is expected.

Previous discussions of SO_2 impacts from the Buckhorn Alternative have focused on the SO_2 emissions from the sulfur recovery tail gas incinerators. These are by far the largest sources of SO_2. There would also be SO_2 emissions above the EPA's PSD de minimis level of 40 tons/year due to emergency plant flaring of the feed gas to plants or modules. These emissions are expected to be 284 tons/year from Exxon at East and West Dry Basin, 127 tons/year from Northwest at Craven Creek, and 162 tons/year from American Quasar at Buckhorn. However, impacts from flaring are exempt from compliance with PSD increments and ambient air standards. It is anticipated that emergency upset flaring operations would result in relatively high SO_2 concentrations. However, these upsets, if they occur at all, are expected to be very short in duration (one hour or less). Therefore, concentrations would decrease rapidly with distance downwind and with time. Negligible impacts from flaring are expected in Class I areas. For this reason SO_2 concentrations from emergency plant flaring are not expected to be significant.

Nitrogen Dioxide

At the Exxon East Dry Basin facility and American Quasar's Buckhorn facility, the NO_x emissions are 28.9 and 5.9 tons/year respectively, less than EPA's PSD de minimis level of 40 tons/year. At Exxon's and American Quasar's molten sulfur loadout, the NO_x emissions are negligible. These emissions would have some small effect on total NO_2 concentrations in the area. However, based on the very small magnitude of the emission rates, they are not expected to cause or contribute to a violation of the annual NO_2 NAAQS/WAAQS. Therefore, impacts from the Exxon East Dry Basin and American Quasar Buckhorn gas treatment plants and the sulfur loadout are considered insignificant.



MAP 2-2 LOCATIONS OF MAXIMUM 24-HOUR AVERAGE SO_2 CONCENTRATIONS IN PSD CLASS I AND CLASS II AREAS FOR THE BUCKHORN ALTERNATIVE

TABLE 2-27

TOTAL MAXIMUM SO_2 IMPACTS
BUCKHORN ALTERNATIVE

Time Period	Maximum Predicted Concentration[1] (μg/m^3)	Representative Background Concentration (μg/m^3)	Total SO_2 Concentration[1] (μg/m^3)	Applicable NAAQS/WAAQS
3-Hour	278	70	348	1,300
24-Hour	62 (162)	15	77 (177)	365
Annual	7	3	10	80

[1] Concentrations in parentheses represent modeling estimates using hypothetical "worst-case" screening conditions.

However, Northwest Pipeline plans to operate auxilliary stream boilers whose emissions (92.5 tons/year) are about twice as high as the EPA de minimis cutoff of 40 tons/year. Also, the Exxon West Dry Basin facility has NO_x emissions (49.7 tons/year) slightly greater than the 40 ton/year de minimis cutoff. The Northwest Pipeline NO_x emissions were modeled according to the procedures specified in Chapter 3 (assuming all NO_x is converted to NO_2). The modeled maximum annual average is about 1 microgram/cubic meter at the eastern plant boundary. When added to a background value of 9 micrograms/cubic meter, the 10 micrograms/cubic meter total is well below the NAAQS/WAAQS of 100 micrograms/cubic meter. Therefore, insignificant NO_2 impact is expected from Northwest's facility at Craven Creek. Since Exxon's West Dry Basin NO_x emissions are much lower than those from Northwest's Craven Creek facility, it was assumed maximum NO_2 concentrations in the vicinity of the West Dry Basin facility would also be below the 100 microgram/cubic meter NAAQS/WAAQS. Therefore, insignificant NO_2 impact is expected from Exxon's West Dry Basin facility.

Total Suspended Particulate

The gas treatment plants and sulfur loadout would be very small sources of particulates. Emissions from all plants and ancillary facilities are below EPA's de minimis emission rate of 25 tons/year. Therefore, insignificant TSP impact is expected from the Buckhorn Alternative.

Carbon Monoxide

The only source of CO above the EPA de minimis emission level of 100 tons/year is the Northwest tail gas incinerator at Craven Creek (6,084 tons/year). These emissions were modeled with techniques described in Chapter 3. Including representative background CO concentrations of 3,500 and 1,500 micrograms/cubic meter, the maximum total 1-hour and 8-hour concentrations are 3,906 micrograms/cubic meter and 1,805 micrograms/cubic meter, respectively. These are well below the NAAQS/WAAQS of 40,000 micrograms/cubic meter and 10,000 micrograms/cubic meter, respectively. Therefore, it is concluded that operation of the gas treatment plants in the Buckhorn Alternative would not cause significant CO impacts.

Hydrogen Sulfide

Because maximum H_2S impacts occur from individual facilities, the results in the Proposed Action also apply to the Buckhorn Alternative except for the American Quasar facility. Table 2-28 summarizes maximum H_2S impacts for the Buckhorn Alternative. The maximum predicted H_2S concentration from the American Quasar facility at the Buckhorn plant boundary is 65 micrograms/cubic meter with actual off-site meteorology (57 micrograms/cubic meter with worst-case assumed meteorology). Furthermore, the sequential modeling shows that the half-hour H_2S standard of 40 micrograms/cubic meter would be exceeded more than twice in any five consecutive days. Therefore, H_2S emissions from American Quasar's plant at Buckhorn would result in significant H_2S impacts. These conclusions should be verified in the PSD review by remodeling with representative on-site meteorological data and more precise engineering plot plans, once the information is available.

The H_2S emissions in the Buckhorn Alternative were also modeled to determine if maximum 1/2-hour concentrations could exceed the odor threshold of 6.5

TABLE 2-28

MAXIMUM MODELED H_2S
BUCKHORN ALTERNATIVE

Plant Site	Capacity (Million SCFD)	Company	½-Hour H_2S Concentrations[1]/WAAQS[2] (µg/m^3)	
			40, 70	40, 70
West Dry Basin	600	Exxon	12	(9)
East Dry Basin	600	Exxon	7	(5)
Buckhorn	1,200	American Quasar	65	(57)
Craven Creek	400	Northwest Pipeline	3	(3)

[1] These concentrations were evaluated at the plant boundary and beyond because the H_2S WAAQS do not apply within plant property. Concentrations in parentheses are based on hypothetical "worst-case" meteorology. Concentrations for actual off-site meteorology are higher than with "worst-case" assumed meteorology because the "worst-case" assumed meteorology is "F" stability and 2.5 meters/second wind speed (typical assumption by EPA Region VIII and WDEQ, whereas the actual off-site meteorological data contains several hourly occurrences of "F" stability and wind speeds lower than 2.5 meters/second. The lower wind speed results in less plume dilution and consequently higher ½-hour H_2S concentrations.

[2] The WAAQS are shown immediately beneath the column heading. Concentrations underscored exceed one or both of the WAAQS. The 40 micrograms/cubic meter-limit is not to be exceeded more than twice in any five consecutive days and the 70 micrograms/cubic meter limit is not to be exceeded more than twice in any year.

micrograms/cubic meter in Big Piney, LaBarge, Marbleton, and Opal. These are the towns closest to the proposed gas treatment plant sites. The model results for the Exxon facilities at West Dry Basin and East Dry Basin indicate H_2S odors may potentially be detectable only in high terrain surrounding each 600 million SCFD facility. The high terrain significantly impacted is about 3 kilometers to the west-southwest of West Dry Basin and about 1 kilometer to the southeast of East Dry Basin. However, concentrations in Big Piney, LaBarge, and Marbleton are expected to be below the significance criterion (maximum H_2S concentration is 0.2 micrograms/ cubic meter in Big Piney). Maximum concentrations in all proposed and existing PSD Class I areas are expected to be negligible from Exxon's facilities at Big Mesa and West Dry Basin.

The American Quasar significant odor impacts are predicted to occur out to about 6 kilometers of the stacks at Buckhorn in all directions. The lower buoyancy of American Quasar's emissions results in larger impact areas. However, maximum concentrations of H_2S in any nearby towns are not expected to exceed the significance criterion (maximum H_2S concentrations is 3.8 micrograms/ cubic meter in Big Piney). Concentrations in all proposed and existing Class I areas are expected to be negligible.

Hydrogen sulfide from the Northwest Pipeline Craven Creek facility would not exceed the odor significance criterion of 6.5 micrograms/cubic meters in any areas surrounding the facility. In Opal, the nearest town, maximum H_2S is predicted to be 1.0 micrograms/cubic meter. Maximum H_2S levels in all proposed and existing Class I areas are expected to be negligible.

Based on the results presented above, maximum H_2S concentrations will likely exceed the odor significance criterion of 6.5 micrograms/cubic meter within 6 kilometers of the American Quasar stacks and in isolated high terrain areas around the Exxon facilities. Therefore, significant odor impacts are expected in these areas. However, insignificant odor impacts are expected in all areas surrounding the Northwest facility, in all nearby towns, and in all proposed and existing PSD Class I areas.

Because of individual differences to odor sensitivity, some people may be able to detect odors at distances greater than predicted in this analysis.

Carbonyl Sulfide

The maximum modeled COS concentrations from the Proposed Action also apply to the Buckhorn Alternative except for American Quasar's facility at Buckhorn. Maximum COS concentrations are summarized in Table 2-29. The maximum annual average COS concentrations are: Exxon at East Dry Basin-3 micrograms/cubic meter; Exxon at West Dry Basin-5 micrograms/cubic meter; American Quasar's plant at Buckhorn-10 micrograms/cubic meter; and Northwest Pipeline's facility at Craven Creek-0.04 micrograms/cubic meter.

The maximum modeled 8-hour COS concentrations are also the same as for the Proposed Action (except for American Quasar's facility at Buckhorn and Exxon at East Dry Basin). The maximum 8-hour average COS concentrations are: Exxon at East Dry Basin-66 micrograms/cubic meter; Exxon at West Dry Basin-225 micrograms/cubic meter; American Quasar's plant at Buckhorn-83 micrograms/cubic meter; and Northwest Pipeline's facility at Craven Creek-1 microgram/cubic meter.

TABLE 2-29

MAXIMUM MODELED COS CONCENTRATIONS

BUCKHORN ALTERNATIVE

Plant Site	Annual Average COS Concentrations/MEG[1] ($\mu g/m^3$)
	800
West Dry Basin (Exxon)	5
East Dry Basin (Exxon)	3
Buckhorn (American Quasar)	10
Craven Creek (Northwest Pipeline)	0.04

Plant Site	8-Hour Average COS Concentrations/Toxicity Value[2] ($\mu g/m^3$)
	60,000
West Dry Basin (Exxon)	225
East Dry Basin (Exxon)	66
Buckhorn (American Quasar)	83
Craven Creek (Northwest Pipeline)	1

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[1] The MEG stands for EPA's multi media environmental goal. Its value is shown immediately beneath the column heading.

[2] The toxicity value is shown immediately beneath the column heading.

Based on the significance criteria of 800 micrograms/cubic meter (annual average) and 60,000 micrograms/cubic meter, (8-hour average), significant COS impact is not expected from any facilities.

Annual average COS concentrations from all facilities emissions combined were also evaluated. The maximum predicted concentration of 10 micrograms/cubic meter is well below the significance criterion of 800 micrograms/cubic meter. Therefore, insignificant COS impact is expected in all areas for the Buckhorn Alternative.

Carbon Dioxide

Emissions of CO_2 are not expected to cause a general climatic warming, although considerable uncertainty exists regarding the potential for the "greenhouse effect".

The maximum predicted annual average CO_2 concentrations summarized for the Proposed Action also represent the Buckhorn Alternative except for the American Quasar facility at Buckhorn. Because the Buckhorn site is in low terrain, maximum expected CO_2 concentrations from the modestly buoyant American Quasar CO_2/nitrogen vents would actually be lower than American Quasar CO_2 concentrations at East Dry Basin. Their maximum CO_2 concentration is predicted to be 0.2 grams/cubic meter which is lower than the significance criterion of 11 grams/cubic meter. Therefore, the American Quasar facility at Buckhorn would not result in significant CO_2 impacts. The Exxon facilities at East and West Dry Basin and the Northwest facility at Craven Creek would also not result in significant CO_2 impacts in the plant area because their predicted concentrations are 0.01, 0.02, and 0.004 grams/cubic meter, respectively.

Helium

Helium would be vented from all gas treatment plants if it is not purified and sold. However, as discussed in detail in Chapter 3, ground level He concentrations, in the work places of all treatment plants, are expected to be well below the 30,000 parts/million required to cause asphyxiation. Therefore, no significant He impacts are expected.

ACID DEPOSITION IN CLASS I AREAS

The potential acute changes to water chemistry in the Bridger Wilderness resulting from the Buckhorn Alternative are presented in Table 2-30. The largest pH changes are predicted to occur at Clear Lake (south), ranging between decreases of 0.09-0.17 pH. Decreases at Hobbs Lake and Clear Lake (north) are predicted to be less than or equal to 0.05 pH. Resulting pH values at all lakes should not drop below 6.28, indicating that no significant impacts should occur to fish populations or habitat.

Long-term pH changes have not been assessed due to a lack of data. Additional data measurement recommendations are given in the discussion of the Proposed Action.

VISIBILITY IMPAIRMENT IN PSD CLASS I AREAS

At the Bridger Wilderness and at the Scab Creek Primitive Area, visibility impairment from the Buckhorn Alternative may be slightly greater than for

TABLE 2-30

ESTIMATED EFFECTS ON WATER CHEMISTRY OF THREE LAKES IN THE BRIDGER WILDERNESS, BUCKHORN ALTERNATIVE

	Clear Lake (North)	Hobbs Lake	Clear Lake (South)
Baseline pH	6.60	6.50	6.45
Measured Alkalinity (eq/ℓ x 10^{-6})	110.0	112.0	85.0
Calculated Alkalinity (eq/ℓ x 10^{-6})	19.95	15.85	14.13
Incremental H^+ Input (eq/ℓ x 10^{-6})	0.23 - 0.45	0.59 - 1.17	2.01 - 4.02
Remaining Alkalinity (eq/ℓ x 10^{-6})	19.72 - 19.50	15.26 - 14.68	12.12 - 10.11
Resulting pH	6.59 - 6.59	6.48 - 6.47	6.38 - 6.30
ΔpH	0.01	0.02 - 0.03	0.07 - 0.15
After accounting for the potential effect of the freezing point depression of acidic snow:			
Resulting pH	6.55 - 6.55	6.48 - 6.47	6.38 - 6.30
ΔpH	0.05	0.02 - 0.03	0.07 - 0.15
After accounting for the potential effect of plant flaring:			
Resulting pH	6.55 - 6.55	6.48 - 6.47	6.36 - 6.28
ΔpH	0.05	0.02 - 0.03	0.09 - 0.17

the Proposed Action because the American Quasar plant and one of Exxon's plants would be closer to these areas. However, EPA Level 1 calculations show that all three indices of potential impairment would be below the critical value of 0.1. Therefore, significant visibility impairment is not expected in any of the existing or proposed Class I areas.

IMPACTS TO VEGETATION AND SOILS IN PSD CLASS I AREAS

No significant impact is expected from the Buckhorn Alternative to sensitive vegetation, i.e., lichens because it is expected that applicable PSD increments for SO_2 and TSP would be met.

SECONDARY GROWTH IMPACTS

Table 2-31 summarizes the predicted pollutant concentrations which include representative background values. The town-by-town population and emissions increases for the Buckhorn Alternative are the same as those of the Proposed Action. All predicted maximum concentrations are below applicable NAAQS/WAAQS. Therefore, predicted impacts are expected to be insignificant.

AIR QUALITY RELATED VALUES IMPACTS

As dicussed above, impacts to the AQRV odor, visibility, flora (due directly from SO_2 and particulate) and acid deposition effects on trout (due directly from pH changes) in sensitive high altitude lakes are expected to be insignificant. However, it is unknown whether impacts to the other AQRV, i.e., flora (for example from acid deposition), fauna (other than sensitive fish), water, soil, cultural/archeological, and geologic would be significant.

SUMMARY OF THE BUCKHORN ALTERNATIVE OPERATIONS-RELATED IMPACTS

Operation of the Buckhorn Alternative is expected to result in insignificant air quality impacts except for the following:

1) The maximum half-hour H_2S concentrations from American Quasar's plant at Buckhorn are expected to exceed the one-half hour 40 microgram/cubic meter WAAQS more than twice in any five consecutive days. The maximum one-half hour H_2S concentrations for each gas treatment plant using actual, off-site meteorological data (and assumed worst-case meteorology) are: 65 (57) micrograms/cubic meter. Significant odor impacts are also expected due to H_2S out to 6 kilometers from the Buckhorn site, and in isolated high terrain immediately surrounding the Exxon facilities because the maximum predicted concentrations from these facilities are 65, 12 and 7 micrograms/cubic meter, respectively, which exceed the odor significance criterion of 6.5 micrograms/cubic meter.

IMPACTS OF THE SHUTE CREEK ALTERNATIVE

The Shute Creek Alternative is similar to the Buckhorn Alternative except both of Exxon's 600-million SCFD facilities would be combined into one 1.2-billion SCFD facility at Shute Creek. The American Quasar 1.2-billion SCFD facility would be at the Buckhorn site and Northwest Pipeline's 400-million SCFD facility would be at Craven Creek. Refer to Map 1-1 (map pocket) for the site locations.

TABLE 2-31

AIR QUALITY IMPACT OF SECONDARY GROWTH ON THE KEMMERER-DIAMONDVILLE AREA

BUCKHORN ALTERNATIVE

	Total Maximum Concentrations/NAAQS/WAAQS ($\mu g/m^3$)									
	1-Hour		3-Hour		8-Hour		24-HOur		Annual	
Pollutant	Conc.	Std	Conc	Std	Conc	Std	Conc	Std	Conc	Std
TSP	--	--	--	--	--	--	62.4[5]	150	30.6[7]	60
SO_2	--	--	70.4[2]	1,300	--	--	15.1[6]	365	3.03[8]	80
NO_x	--	--	--	--	--	--	--	--	9.3[9]	100
CO	3,623[1]	40,000	--	--	1,593[4]	10,000	--	--	--	--
HC	--	--	8.3[3]	160	--	--	--	--	--	--

[1] Includes a background concentration of 3,500 micrograms/cubic meter.

[2] Includes a background concentration of 70 micrograms/cubic meter.

[3] Does not include a background concentration. Background is unknown but probably very low.

[4] Includes a background concentration of 1,500 micrograms/cubic meter.

[5] Includes a background concentration of 60 micrograms/cubic meter.

[6] Includes a background concentration of 15 micrograms/cubic meter.

[7] Includes a background concentration of 30 micrograms/cubic meter.

[8] Includes a background concentration of 3 micrograms/cubic meter.

[9] Includes a background concentration of 9 micrograms/cubic meter.

PROPOSED WELL DRILLING OPERATIONS

The Shute Creek Alternative does not effect the air quality impacts of the proposed well drilling operations. The impacts of this alternative are identical to those described in the Proposed Action. No significant impacts are expected.

GAS TREATMENT PLANT CONSTRUCTION

Table 2-32 presents the predicted TSP concentrations from construction activities at the gas treatment plant sites. All concentrations are below the 60 micrograms/cubic meter NAAQS/WAAQS and are therefore insignificant. The maximum impact of 47 micrograms/cubic meter occurs at the proposed Northwest plant site at Craven Creek.

For reasons discussed in detail under the Proposed Action, combined impacts from concurrent, but spatially separated construction sources are not expected to be significantly greater than TSP impacts from individual construction activities. Therefore, insignificant TSP impacts are also expected when considering combined effects of all sources.

OPERATION OF THE WELL FIELD

Normal emissions during well field operations are below the EPA de minimis emissions levels and therefore, would result in insignificant impacts. Upset conditions could result in flaring of well field gas, likely resulting in SO_2 concentrations exceeding the 3-hour NAAQS/WAAQS of 1,300 micrograms/cubic meter if poor atmospheric dispersion exists. However, as discussed in the Proposed Action, the probability of flaring occurring during poor dispersion conditions has been calculated to be less than 1:100,000 for Exxon and about 3:10,000 for Northwest. Therefore, no significant impact is expected.

OPERATION OF THE GAS TREATMENT PLANTS

Sulfur Dioxide

Table 2-33 contains the maximum modeled SO_2 concentrations in PSD Class II areas from individual plant operations. The maximum impacts from Exxon's Shute Creek facility occur in high terrain under stable conditions. Although maximum concentrations under hypothetical "worst-case" meteorology indicate significant 24-hour SO_2 impacts for the Buckhorn and Craven Creek facilities, maximum modeled impacts with actual off-site meteorological data are below the PSD Class II increment of 91 micrograms/cubic meter. Maximum modeled 3-hour and annual impacts are also below applicable increments.

For Exxon's facility at Shute Creek, the maximum predicted 3-hour and 24-hour SO_2 concentrations occurred a little more than 4 kilometers to the south of the Shute Creek plant site. Quasar's 3-hour and 24-hour impacts from the Buckhorn facility occur at the same locations as described in the Buckhorn Alternative. Northwest's 3-hour and 24-hour SO_2 impacts from the Craven Creek plant occur at the same locations as described in the Proposed Action.

Tables 2-34 and 2-35 summarize maximum predicted impacts in existing and proposed Class I areas, respectively, from individual gas treatment plants comprising the Shute Creek Alternative. Predicted concentrations above the

TABLE 2-32

MAXIMUM MODELED TSP CONCENTRATIONS FROM CONSTRUCTION OF SHUTE CREEK ALTERNATIVE[1]

Plant Site/Company	Annual Average Concentration ($\mu g/m^3$)			
	Modeled	Background	Total	NAAQS/WAAQS
Shute Creek/Exxon	15	30	45	60
Buckhorn/Am Quasar	13	30	43	60
Craven Creek/Northwest	17	30	47	60
Sulfur Loadout	2	30	32	60

[1] Impacts from concurrent construction activities at other sites are expected to add (at most) 1 microgram/cubic meter to these concentrations. This results in a maximum predicted impact of 48 micrograms/cubic meter at Craven Creek, below the 60 microgram/cubic meter NAAQS/WAAQS.

TABLE 2-33

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PSD CLASS II AREAS

SHUTE CREEK ALTERNATIVE

Company	Plant Site	Capacity (Million SCFD)	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)		
			3-hour 512	24-hour[2] 91	Annual 20
Exxon	Shute Creek	1,200	207	39 (55)	7
American Quasar	Buckhorn	1,200	37	14 (97)	7
Northwest Pipeline	Craven Creek	400	159	50 (94)	4

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-34

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN EXISTING PSD CLASS I AREAS
SHUTE CREEK ALTERNATIVE

	Maximum SO_2 Concentrations/PSD Increments[1] (µg/m^3)								
	Bridger Wilderness			Teton Wilderness			Teton National Park		
	3-hour	24-hour[2]	Annual	3-hour	24-hour[2]	Annual	3-Hour	24-Hour[2]	Annual
Plant Site	25	5	2	25	5	2	25	5	2
Shute Creek	1.6	0.4 (0.7)	0.02	1.2	0.2 (0.7)	0.02	1.2	0.2 (0.8)	0.01
Buckhorn	14.6	3.0 (6.8)	0.28	3.7	0.6 (2.0)	0.07	3.1	0.6 (2.1)	0.05
Craven Creek	2.1	0.4 (0.9)	0.05	1.4	0.2 (0.7)	0.02	1.2	0.3 (0.9)	0.02

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-35

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PROPOSED PSD CLASS I AREAS

SHUTE CREEK ALTERNATIVE

Plant Site	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)					
	Scab Creek Primitive Area			Fossil Butte National Monument		
	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2
Shute Creek	2.8	0.6 (1.3)	0.03	8.5	2.2 (4.0)	0.07
Buckhorn	16.8	4.3 (8.2)	0.37	7.6	1.4 (4.0)	0.14
Craven Creek	3.4	0.7 (1.5)	0.04	11.7	3.0 (6.2)	0.12

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

Class I SO_2 increments are underscored. Results show that actual off-site meteorological data predict that all individual facilities in the Shute Creek Alternative would comply with Class I increments in all areas. However, the assumed "worst-case" meteorology indicates concentrations higher than the 24-hour Class I increment at the Bridger Wilderness and Scab Creek Primitive Area from SO_2 emissions at Buckhorn, and at Fossil Butte National Monument from emissions at Craven Creek.

Based on results from actual off-site meteorology presented in Tables 2-33 through 2-35, it is unlikely that the individual facilities comprising the Shute Creek Alternative would have significant SO_2 impact in Class I and II areas (notwithstanding the predicted high concentrations from hypothetical, "worst-case" meteorology). However, these conclusions should be checked in the PSD review process with representative on-site data, once available.

The maximum predicted combined impacts in PSD Class II areas are summarized in Table 2-36. The maximum concentrations are: 3-hour average - 207 micrograms/cubic meter (from Exxon's Shute Creek facility alone); 24-hour average - 52 micrograms/cubic meter with actual off-site meteorology (from the combined impacts of Exxon's Shute Creek facility and Northwest's Craven Creek facility); and 94 micrograms/cubic meter with hypothetical worst-case meteorology (from the Craven Creek facility alone); annual average - 9 micrograms/cubic meter which occurred at a distance of a little more than 5 kilometers to the east-northeast of the Shute Creek plant site. The concentrations, based on actual off-site meteorology, are well below applicable Class II PSD increments.

Table 2-37 summarizes the maximum combined SO_2 impacts in existing and proposed Class I areas for the Shute Creek Alternative. This table shows that maximum combined SO_2 impacts in all existing Class I areas would be below applicable increments using actual off-site meteorology with the exception of maximum predicted 24-hour impacts in the two proposed Class I areas (Scab Creek and Fossil Butte) which are above the allowable 5 micrograms/cubic meter limit. Even so, the highest second-highest concentrations (used to determine compliance with PSD increments) in these two areas are below the Class I 24-hour increment. These concentrations are predicted to be 4.3 micrograms/cubic meter at Scab Creek and 3.9 micrograms/cubic meter at Fossil Butte. With hypothetical worst-case meteorology, SO_2 concentrations exceed the 24-hour Class I PSD increment at the Bridger Wilderness, Scab Creek Primitive Area, and Fossil Butte National Monument.

For the Shute Creek Alterantive, the locations of the maximum 3-hour, 24-hour, and annual SO_2 impacts in all proposed and existing Class I areas are the same as those described in the Proposed Action with the exception of the Bridger Wilderness Area. In the Bridger Wilderness, the maximum predicted impacts for all time averages occur at a distance of about 116 kilometers to the north-northeast of the Shute Creek plant site.

Notwithstanding the SO_2 concentrations predicted with hypothetical worst-case meteorology, it is concluded that combined SO_2 impacts for the Shute Creek Alternative would not result in significant impacts in Class I and Class II areas.

TABLE 2-36

COMBINED SO_2 IMPACTS IN PSD CLASS II AREAS
SHUTE CREEK ALTERNATIVE

Maximum SO_2 Concentrations/PSD Increments (μg/m^3)					
3-Hour		24-Hour[1]		Annual	
Concentration	Increment	Concentration	Increment	Concentration	Increment
207	512	52 (94)	91	9	20

[1] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions. Underscored concentrations are above applicable increment.

TABLE 2-37

COMBINED SO_2 IMPACTS IN EXISTING AND PROPOSED PSD CLASS I AREAS

SHUTE CREEK ALTERNATIVE

Area	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$) 3-hour 25	24-hour[2] 5	Annual 2
Bridger Wilderness (existing Class I area)	17.9	3.7 (8.2)	0.30
Teton Wilderness (existing Class I area)	5.4	0.8 (2.7)	0.10
Teton National Park (existing Class I area)	4.0	0.9 (2.9)	0.04
Scab Creek Primitive Area (proposed Class I area)	20.4	5.1[3] (8.2)	0.42
Fossil Butte National Monument (proposed Class I area)	18.5	5.3[3] (9.9)	0.26

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] Concentrations in parentheses represent modeling estimates using hypothetical "worst-case" meteorology.

[3] The listed values represent the maximum predicted concentrations. The highest second highest values (used for determining compliance with PSD increments, are 4.3 micrograms/cubic meter at Scab Creek and 3.9 micrograms/cubic meter at Fossil Buttes. Both these values are less than the 5 microgram/cubic meter PSD increment.

The locations of the predicted maximum 24-hour SO_2 impacts (from Table 2-33) in Class II areas, and in the proposed and existing Class I areas (from Table 2-37) are presented in Map 2-3. Since 24-hour average impacts are usually more limiting than 3-hour and annual impacts, the locations of the maximum 24-hour impacts are helpful in illustrating the extent of the SO_2 impacts.

Like the Proposed Action and the Buckhorn Alternative, total atmospheric burdens of SO_2 from emissions in the Shute Creek Alternative would not be greater than the 3-hour, 24-hour, and annual NAAQS/WAAQS. Table 2-38 summarizes the total SO_2 burdens. When combined with representative background SO_2 concentrations, the maximum total concentrations from actual offsite meteorological data are: a 277 micrograms/cubic meter 3-hour average, 67 micrograms/cubic meter 24-hour average, and a 12 micrograms/cubic meter annual average. With hypothetical worst-case meteorology the maximum 24-hour average is 109 micrograms/cubic meter. These are well below the applicable SO_2 standards of 1,300, 365, and 80 micrograms/cubic meter, respectively; therefore, insignificant impact is expected.

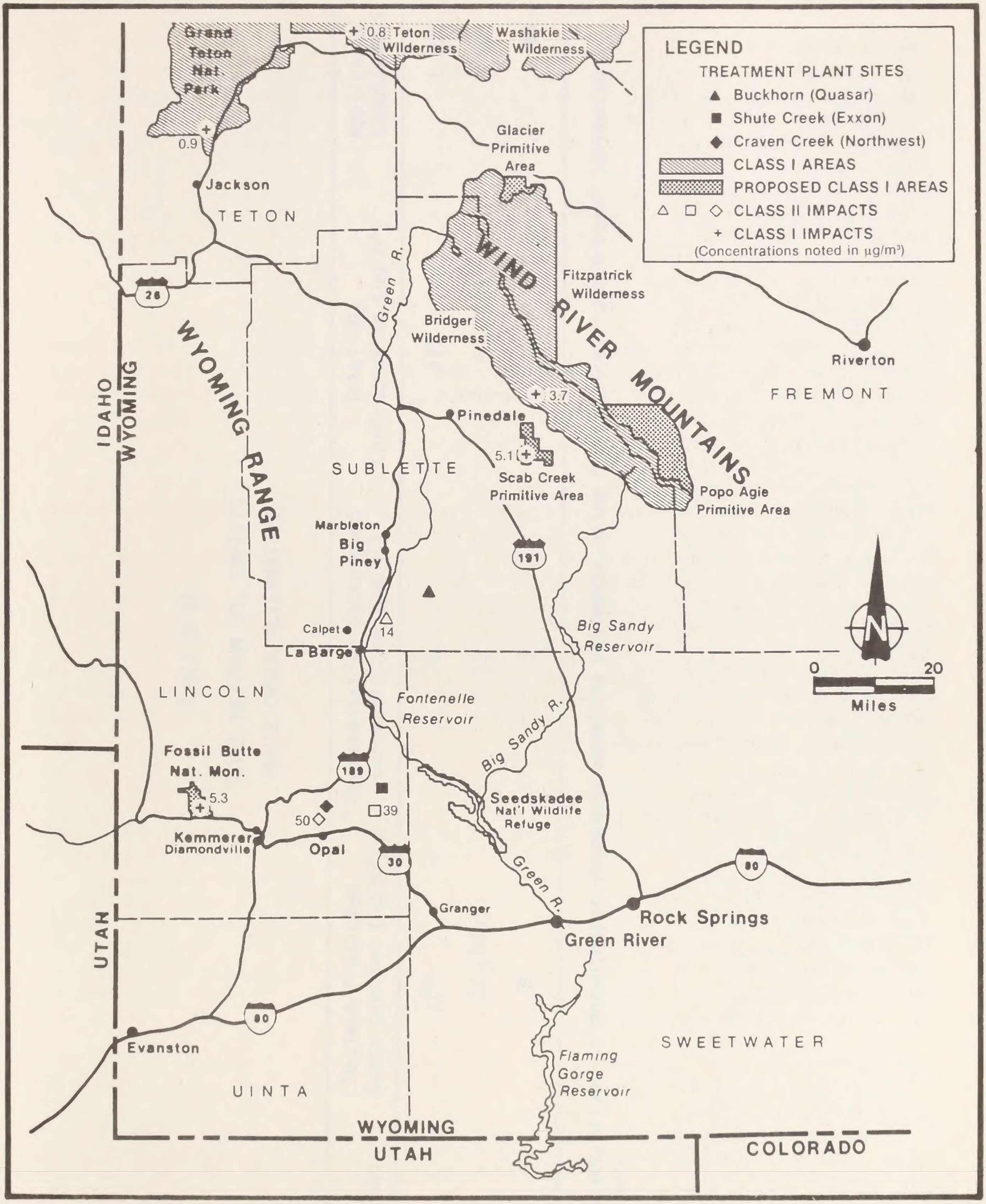
All previous discussions of SO_2 impacts from the Shute Creek Alternative have focused on the SO_2 emissions from the sulfur recovery tail gas incinerators. These are by far the largest sources of SO_2. There would also be SO_2 emissions above the EPA's PSD deminimis level of 40 tons/year due to emergency plant flaring of the feed gas to plants or modules. These emissions are expected to be 284 tons/year from Exxon at Shute Creek, 127 tons/year from Northwest at Craven Creek, and 162 tons/year from American Quasar at Buckhorn. However, impacts from flaring are exempt from compliance with PSD increments and ambient air standards. It is anticipated that emergency upset flaring operations would result in relatively high SO_2 concentrations. However, these upsets, if they occur at all, are expected to be very short in duration (one hour or less). Therefore, concentrations would decrease rapidly with distance downwind and with time. Negligible impacts from flaring are expected in Class I areas. For this reason SO_2 concentrations from emergency plant flaring are not expected to be significant.

Nitrogen Dioxide

The maximum NO_2 impacts from the Shute Creek Alternative are slightly greater than those described for the Proposed Action and the Buckhorn Alternative. The maximum annual average NO_2 is predicted to occur on the eastern boundary of Northwest's Craven Creek plant. The maximum modeled concentration of 2.2 micrograms/cubic meter combined with a background value of 9 micrograms cubic meter results in a total NO_2 concentration of 11.2 micrograms/cubic meter which is well below the NAAQS/WAAQS of 100 micrograms/cubic meter. Thus, insignificant NO_2 impact is expected from the Shute Creek Alternative.

Total Suspended Particulate

The gas treatment plants and sulfur loadout would be very small sources of particulates. Emissions from all plants and ancillary facilities would be below EPA's de minimis emission rate of 25 tons/year. Therefore, insignificant TSP impact is expected from the Shute Creek Alternative.



MAP 2-3 LOCATIONS OF MAXIMUM 24-HOUR AVERAGE SO_2 CONCENTRATIONS IN PSD CLASS I AND CLASS II AREAS FOR THE SHUTE CREEK ALTERNATIVE

TABLE 2-38

TOTAL MAXIMUM SO_2 IMPACTS
SHUTE CREEK ALTERNATIVE

Time Period	Maximum Predicted Concentration (μg/m³)	Representative Background Concentration (μg/m³)	Total SO_2 Concentration (μg/m³)	Applicable NAAQS/WAAQS
3-Hour	207	70	277	1,300
24-Hour	52 (94)	15	67 (109)	365
Annual	9	3	12	80

[1] The concentrations in parentheses represent modeling estimates using hypothetical "worst-case" screening conditions.

Carbon Monoxide

The only source of CO above the EPA de minimis emission level of 100 tons/year is the Northwest tail gas incinerator at Craven Creek (6,084 tons/year). These emissions were modeled with techniques described in Chapter 3. The maximum modeled 1-hour and 8-hour concentrations (including background) are 3,906 micrograms/cubic meter and 1,805 micrograms/cubic meter, respectively. These are well below the NAAQS/WAAQS of 40,000 micrograms/cubic meter and 10,000 micrograms/cubic meter, respectively. Therefore, it is concluded that operation of the gas treatment plants in the Shute Creek Alternative would not cause significant CO impacts.

Hydrogen Sulfide

Because maximum H_2S impacts occur from individual facilities, the conclusions reached in the Buckhorn Alternative also apply to the Shute Creek Alternative except for the proposed Exxon plant at Shute Creek. Table 2-39 summarizes maximum H_2S impacts for the Shute Creek Alternative. The maximum predicted one-half hour H_2S concentrations are: Northwest Pipeline's facility at Craven Creek-3 micrograms/cubic meter (3 micrograms/cubic meter with worst-case meteorology); American Quasar's facility at Buckhorn-65 micrograms/cubic meter (57 micrograms/cubic meter with worst-case assumed meteorology); Exxon's facility at Shute Creek-4 micrograms/cubic meter (4 micrograms/cubic meter with worst-case assumed meteorology). Furthermore, it was determined that American Quasar's facility would exceed the Wyoming 40 micrograms/cubic meter H_2S standard more than allowable (i.e., more than twice in any 5 consecutive days). Therefore, H_2S emissions from American Quasar's plant at Buckhorn would result in significant H_2S impacts. These conclusions should be verified in the PSD review process by remodeling with representative on-site meteorological data and more precise engineering plot plans, once the information is available.

The H_2S emissions in the Shute Creek Alternative were also modeled to determine if maximum 1-hour concentrations could exceed the odor threshold of 6.5 micrograms/cubic meter in Big Piney, LaBarge, Marbleton, Opal, and Kemmerer-Diamondville. These are the towns closest to the proposed gas treatment plant sites. The model results for the Exxon and Northwest facilities indicate H_2S odors would not be detectable at any locations. Concentrations in Opal and Kemmerer-Diamondville are expected to be below the significance criterion (maximum H_2S concentration is 1.4 micrograms/cubic meter at Opal. Maximum concentrations in all proposed and existing PSD Class I areas are expected to be negligible from Exxon's facility at Shute Creek and Northwest's facility at Craven Creek.

The American Quasar significant odor impacts occur out to about 6 kilometers of the stacks at the Buckhorn site. Maximum concentrations of H_2S are not expected to exceed the significance criterion in any nearby towns (maximum H_2S concentration is 3.8 micrograms/cubic meter in Big Piney). Concentrations in all proposed and existing Class I areas are expected to be negligible.

Because of individual differences to odor sensitivity, some people may be able to detect odors at distances greater than predicted in this analysis.

TABLE 2-39

MAXIMUM MODELED H_2S
SHUTE CREEK ALTERNATIVE

Plant Site	Capacity (Million SCFD)	Company	½-Hour H_2S Concentrations[1]/WAAQS[2] ($\mu g/m^3$)	
			40, 70	40, 70
Shute Creek	1,200	Exxon	4	(4)
Buckhorn	1,200	American Quasar	65	(57)
Craven Creek	400	Northwest Pipeline	3	(3)

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[1] These concentrations were evaluated at the plant boundary and beyond because the H_2S WAAQS do not apply within plant property. Concentrations in parentheses are based on hypothetical "worst-case" meteorology. Concentrations for actual off-site meteorology are higher than with "worst-case" assumed meteorology because the "worst-case" assumed meteorology is "F" stability and 2.5 meters/second wind speed (typical assumption by EPA Region VIII and WDEQ, whereas the actual off-site meteorological data contains several hourly occurrences of "F" stability and wind speeds lower than 2.5 meters/second. The lower wind speed results in less plume dilution and consequently higher ½-hour H_2S concentrations.

[2] The WAAQS are shown immediately beneath the column heading. Concentrations underscored exceed one or both of the WAAQS. The 40 micrograms/cubic meter-limit is not to be exceeded more than twice in any five consecutive days and the 70 micrograms/cubic meter limit is not to be exceeded more than twice in any year.

Carbonyl Sulfide

The maximum modeled COS impacts of the Buckhorn Alternative also apply to the Shute Creek Alternative except for Exxon's facility. Maximum COS concentrations are summarized in Table 2-40. The maximum annual COS concentrations are: Exxon at Shute Creek-7 micrograms/cubic meter; American Quasar's plant at Buckhorn-10 micrograms/cubic meter; and Northwest Pipeline's facility at Craven Creek-0.04 micrograms/cubic meter.

The maximum 8-hour average COS concentrations are: Exxon at Shute Creek-91 micrograms/cubic meter; American Quasar's plant at Buckhorn-83 micrograms/cubic meter; and Northwest Pipeline's facility at Craven Creek-1 microgram/cubic meter.

Based on significance criteria of 800 micrograms/cubic meter (annual average) and 60,000 micrograms/cubic meter (8-hour average), no significant COS impact is expected from any facilities.

Annual average COS concentrations from all facilities emissions combined were also evaluated. The highest concentration, 10 micrograms/cubic meter, is well below the significance criterion of 800 micrograms/cubic meter. Therefore, insignificant COS impact is expected in all urban areas for the Shute Creek Alternative.

Carbon Dioxide

Emission of CO_2 are not expected to cause a general climatic warming, although considerable uncertainity exists regarding the potential for the "greenhouse effect". The maximum predicted annual average CO_2 impacts summarized for the Buckhorn Alternative also represent the Shute Creek Alternative except for the Exxon facility at Shute Creek. The CO_2 emissions from the American Quasar facility at Buckhorn would result in a CO_2 concentration of 0.2 grams/cubic meter which is below the 11 grams/ cubic meter significance criterion. Therefore, insignificant CO_2 impacts are expected from the American Quasar facility. The Exxon facility at Shute Creek and the Northwest facility at Craven Creek also would not result in significant CO_2 impacts because their predicted maximum concentrations are 0.03 and 0.04 grams/cubic meter, respectively.

Helium

The He concentrations described in the Proposed Action are very localized and would be everywhere less than the 30,000 parts/million required to cause asphyxiation. Therefore, the conclusions for the Proposed Action and Buckhorn Alternative also apply to the Shute Creek Alternative, i.e., no significant impact.

ACID DEPOSITION IN CLASS I AREAS

The potential acute changes to water chemistry in the Bridger Wilderness resulting from the Shute Creek Alternative are presented in Table 2-41. The largest pH decreases (0.07 to 0.13 pH) are predicted to occur at Clear Lake (South). Decreases at Hobbs Lake and Clear Lake (North) are predicted to be less than 0.03 and 0.05 pH units, respectively. Minimum pH values in all lakes should not drop below 6.32 pH, still within tolerable levels for fish populations and habitat. Therefore, insignificant impact is expected.

TABLE 2-40

MAXIMUM MODELED COS CONCENTRATIONS

SHUTE CREEK ALTERNATIVE

Plant Site	Annual Average COS Concentrations/MEG[1] ($\mu g/m^3$) 800
Shute Creek	7
Buckhorn (American Quasar)	10
Craven Creek (Northwest Pipeline)	0.04

Plant Site	8-Hour Average COS Concentrations/Toxicity Value[2] ($\mu g/m^3$) 60,000
Shute Creek (Exxon)	91
Buckhorn (American Quasar)	83
Craven Creek (Northwest Pipeline)	1

[1] The MEG stands for EPA's multi media environmental goal. Its value is shown immediately beneath the column heading.

[2] The toxicity value is shown immediately beneath the column heading.

TABLE 2-41

ESTIMATED EFFECTS ON WATER CHEMISTRY OF THREE LAKES IN THE BRIDGER WILDERNESS, SHUTE CREEK ALTERNATIVE

	Clear Lake (North)	Hobbs Lake	Clear Lake (South)
Baseline pH	6.60	6.50	6.45
Measured Alkalinity ($eq/l \times 10^{-6}$)	110.0	112.0	85.0
Calculated Alkalinity ($eq/l \times 10^{-6}$)	19.95	15.85	14.13
Incremental H^+ Input ($eq/l \times 10^{-6}$)	0.20 - 0.40	0.48 - 0.97	1.61 - 3.21
Remaining Alkalinity ($eg/l \times 10^{-6}$)	19.75 - 19.55	15.37 - 14.88	12.52 - 10.92
Resulting pH	6.60 - 6.59	6.49 - 6.47	6.40 - 6.34
ΔpH	0.00 - 0.01	0.01 - 0.03	0.05 - 0.11
After accounting for the potential effect of the freezing point depression of acidic snow:			
Resulting pH	6.55 - 6.55	6.49 - 6.47	6.40 - 6.34
ΔpH	0.05	0.01 - 0.03	0.05 - 0.11
After accounting for the potential effect of plant flaring:			
Resulting pH	6.55 - 6.55	6.49 - 6.47	6.38 - 6.32
ΔpH	0.05	0.01 - 0.03	0.07 - 0.13

Long-term pH changes have not been assessed due to a lack of data. Additional data measurement recommendations are given in the discussion of the Proposed Action.

VISIBILITY IMPAIRMENT IN PSD CLASS I AREAS

At the Bridger Wilderness and at Scab Creek Primitive Area, visibility impairment from the Shute Creek Alternative would be slightly less than for the Proposed Action because, even though the American Quasar facility is closer to these Class I areas, the Exxon facility would be much further away. EPA Level 1 screening calculations show that all three indices of potential visibility impairment would be below the critical value of 0.1 for all proposed and existing Class I areas. Therefore, significant visibility impairment is not expected to occur.

IMPACT TO VEGETATION AND SOILS IN PSD CLASS I AREAS

No significant impact is expected to sensitive vegetation, i.e., lichens from the Shute Creek Alternative because it is expected that applicable PSD increments for SO_2 and TSP will be met.

SECONDARY GROWTH IMPACTS

The town-by-town population increases for the Shute Creek Alternative are slightly different than those expected for the Proposed Action and Buckhorn Alternative. Table 2-42 displays the expected population increases for the Shute Creek Alternative. Table 2-43 summarizes maximum modeled concentrations (which include background) and NAAQS/WAAQS. These total pollutant burdens are very low in relation to the standards and would not result in violations of the NAAQS/WAAQS for TSP, SO_2, CO, HC, or NO_2. Therefore, insignificant air quality impacts are expected from secondary growth.

AIR QUALITY RELATED VALUES IMPACTS

As discussed previously impacts to the AQRV odor, visibility, flora (due directly from SO_2 and particulate) and acid deposition effects on trout (due directly from pH changes) in sensitive high altitude lakes are expected to be insignificant. However, it is unknown whether impacts to the other AQRV, i.e., flora (for example from acid deposition), fauna (other than sensitive fish), water, soil, cultural/archeological, and geologic would be significant.

SUMMARY OF THE SHUTE CREEK ALTERNATIVE OPERATIONS-RELATED IMPACTS

Operation of the Shute Creek Alternative is expected to result in insignificant air quality impacts except for the following:

1) The maximum half-hour H_2S concentrations from American Quasar's plant at Buckhorn are expected to exceed the one-half hour 40 micrograms/cubic meter WAAQS more than twice in any five consecutive days. The maximum one-half hour H_2S concentrations using actual, off-site meteorological data (and assumed worst-case meteorology) are: 65 (57) micrograms/cubic meter. Significant odor impacts from H_2S are also expected out to about 6 kilometers from the Buckhorn site because the maximum predicted concentration of 65 micrograms/cubic meter exceeds the odor significance criterion of 6.5 micrograms/cubic meter.

TABLE 2-42

MAXIMUM ESTIMATED POPULATION INCREASE FROM RILEY RIDGE PROJECT SHUTE CREEK ALTERNATIVE

County	Community	Population Increase[1]	Year
Lincoln	Afton	22	1986
	Cokeville	68	1986
	Diamondville	1,593	1986
	Kemmerer	2,764	1986
	LaBarge	928	1985
	Thayne	6	1985
Sublette	Big Piney	609	1985
	Marbleton	564	1985
	Pinedale	124	1985
Sweetwater	Granger	145	1986
	Green River	632	1986
	Rock Springs	505	1985
	South Superior	35	1985
	Wamsutter	15	1985

Source: Western Research Corporation; Laramie, Wyoming (1982)

[1] Based on County Level Economic Analysis

TABLE 2-43

AIR QUALITY IMPACT OF SECONDARY GROWTH ON THE KEMMERER-DIAMONDVILLE AREA

SHUTE CREEK ALTERNATIVE

	Total Maximum Concentrations/NAAQS/WAAQS ($\mu g/m^3$)									
	1-Hour		3-Hour		8-Hour		24-Hour		Annual	
Pollutant	Conc.	Std	Conc	Std	Conc	Std	Conc	Std	Conc	Std
TSP	--	--	--	--	--	--	62.9[5]	150	30.8[7]	60
SO_2	--	--	70.3[2]	1,300	--	--	15.1[6]	365	3.03[8]	80
NO_x	--	--	--	--	--	--	--	--	9.4[9]	100
CO	3,654[1]	40,000	--	--	1,615[4]	10,000	--	--	--	--
HC	--	--	10.3[3]	160	--	--	--	--	--	--

[1] Includes a background concentration of 3,500 micrograms/cubic meter.

[2] Includes a background concentration of 70 micrograms/cubic meter.

[3] Does not include a background concentration. Background is unknown but is expected to be low.

[4] Includes a background concentration of 1,500 micrograms/cubic meter.

[5] Includes a background concentration of 60 micrograms/cubic meter.

[6] Includes a background concentration of 15 micrograms/cubic meter.

[7] Includes a background concentration of 30 micrograms/cubic meter.

[8] Includes a background concentration of 3 micrograms/cubic meter.

[9] Includes a background concentration of 9 micrograms/cubic meter.

IMPACTS OF THE NORTHERN ALTERNATIVE

The Northern Alternative would place all gas treatment plants at the northern most Riley Ridge sites. Exxon would operate two 600-million SCFD facilities, one at Big Mesa and one at West Dry Basin. Northwest Pipeline would treat 400 million SCFD of sour gas at the East Dry Basin site, and American Quasar would process 1.2 billion SCFD of sour gas at the Buckhorn site. Refer to Map 1-1 (map pocket) for the site locations.

PROPOSED WELL DRILLING OPERATIONS

The Northern Alternative does not affect the air quality impacts of the proposed well drilling operations. The impacts of this alternative are identical to those described in the Proposed Action. No significant impacts are expected.

GAS TREATMENT PLANT CONSTRUCTION

Table 2-44 presents the predicted TSP concentrations from construction activities at the gas treatment plant sites. All concentrations are below the 60 micrograms/cubic meter NAAQS/WAAQS and are therefore insignificant. The maximum impact of 47 micrograms/cubic meter occurs at the proposed Northwest plant site at East Dry Basin.

For reasons discussed in detail under the Proposed Action, combined impacts from concurrent, but spatially separated construciton sources are not expected to be significantly greater than TSP impacts from individual construction activities. Therefore, insignificant TSP impacts are also expected when considering the combined effects of all sources.

OPERATION OF THE WELL FIELD

Normal emissions during well field operations are below the EPA de minimis emission levels and therefore result in insignificant impacts. Upset conditions could result in flaring of well field gas, likely resulting in SO_2 concentrations exceeding the 3-hour NAAQS/WAAQS of 1,300 micrograms/cubic meter if poor atmospheric dispersion exists. However, as discussed in the Proposed Action, the probability of flaring occurring during poor dispersion conditions has been calculated to be less than 1:100,000 for Exxon and 3:10,000 for Northwest. Therefore, no significant impact is expected.

OPERATION OF THE GAS TREATMENT PLANTS

Sulfur Dioxide

Table 2-45 displays the maximum modeled SO_2 concentrations in PSD Class II areas from individual plant operations. Maximum 24-hour concentrations with assumed "worst-case" meteorology for the East Dry Basin, West Dry Basin, and Buckhorn facilities are 174, 162, and 97 micrograms/cubic meter, respectively, which exceed the PSD increment of 91 micrograms/cubic meter. However, actual off-site meteorological data indicates that maximum 24-hour SO_2 concentrations from the Big Mesa, West Dry Basin, Buckhorn, and East Dry Basin facilities are: 30, 62, 14, and 68 micrograms/cubic meter, respectively, which comply with the 24-hour PSD Class II increment. Actual off-site meteorology, also indicates all facilities individually, would comply with 3-hour and annual PSD Class II increments.

TABLE 2-44

MAXIMUM MODELED TSP CONCENTRATIONS FROM CONSTRUCTION OF NORTHERN ALTERNATIVE[1]

Plant Site/Company	Annual Average Concentration (μg/m³)			
	Modeled	Background	Total	NAAQS/WAAQS
West Dry Basin/Exxon	10	30	40	60
Big Mesa/Exxon	10	30	40	60
Buckhorn/Am Quasar	13	30	43	60
East Dry Basin/Northwest	17	30	47	60
Sulfur Loadout	2	30	32	60

[1] Impacts from concurrent construction activities at other sites are expected to add (at most) 1 microgram/cubic meter to these concentrations. This results in a maximum predicted impact of 48 micrograms/cubic meter at Craven Creek, below the 60 microgram/cubic meter NAAQS/WAAQS.

TABLE 2-45

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PSD CLASS II AREAS

NORTHERN ALTERNATIVE

Company	Plant Site	Capacity (Million SCFD)	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)		
			3-hour 512	24-hour[2] 91	Annual 20
Exxon	Big Mesa	600	141	30 (83)	2
Exxon	West Dry Basin	600	278	62 ($\underline{162}$)	6
American Quasar	Buckhorn	1,200	37	14 ($\underline{97}$)	7
Northwest Pipeline	East Dry Basin	400	276	68 ($\underline{174}$)	8

[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

For Northwest's facility at East Dry Basin, the maximum predicted 3-hour SO_2 concentration occurred almost 4 kilometers to the southwest of the plant in high terrain. The maximum 24-hour average SO_2 concentration was predicted to occur a little more than 1 kilometer to the southeast of the plant site in high terrain. Exxon's maximum predicted 3-hour and 24-hour SO_2 concentrations from the Big Mesa and West Dry Basin plants occur at the same locations as those described in the Proposed Action. Quasar's maximum predicted 3-hour and 24-hour SO_2 concentrations from the Buckhorn plant occur at the same locations as those described in the Buckhorn Alternative.

Tables 2-46 and 2-47 delineate maximum modeled SO_2 impacts in existing and proposed Class I areas, respectively, from individual gas treatment plants comprising the Northern Alternative. Results show that actual off-site meteorological data predict compliance with all increments in all proposed and existing Class I areas. However, use of assumed "worst-case" meteorology indicates 24-hour average SO_2 concentrations would be exceeded at the Bridger Wilderness, and the Scab Creek Primitive Area from the Buckhorn SO_2 emissions.

Based on results presented in Tables 2-45 through 2-47, it is unlikely that the individual facilities comprising the Northern Alternative would have significant SO_2 impact in Class I and II areas (notwithstanding the predicted high 24-hour concentrations from hypothetical "worst-case" meteorology). However, conclusions should be checked in the PSD review process with representative on-site data, once available.

Table 2-48 summarizes combined SO_2 impacts in PSD Class II areas. The maximum combined SO_2 annual average impact in Class II areas is 9 micrograms/cubic meter which is below the Class II increment of 20 micrograms/cubic meter and was predicted to occur at a location a little more than 1 kilometer to the southeast of Northwest's East Dry Basin Plant site. Combined 3-hour and 24-hour SO_2 impacts in Class II areas are not greater than maximum individual impacts.

Table 2-49 summarizes the maximum combined SO_2 impacts in proposed and existing Class I areas. The results for actual off-site meteorology show that maximum combined SO_2 impacts in the Teton Wilderness, Teton National Park, and Fossil Buttes would be below applicable increments. In all proposed and existing Class I areas, maximum 3-hour and annual average SO_2 concentrations are expected to be below the applicable increments of 25 and 2 micrograms/cubic meter, respectively.

However, maximum modeled 24-hour average concentrations with actual off-site meteorology in the Bridger Wilderness (5.5 micrograms/cubic meter) and Scab Creek Primitive Area (6.5 micrograms/cubic meter) would exceed the Class I increment of 5 micrograms/cubic meter. Even so, the highest second-highest 24-hour average SO_2 concentrations (used to determine compliance with PSD increments) in each of the areas are below 5 micrograms/cubic meter. These values are 3.9 micrograms/cubic meter at Bridger and 4.7 micrograms/cubic meter at Scab Creek.

For the Northern Alternative, the locations of the maximum 3-hour, 24-hour and annual SO_2 impacts in all proposed and existing Class I areas are the same as those described in the Proposed Action.

TABLE 2-46

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN EXISTING PSD CLASS I AREAS NORTHERN ALTERNATIVE

	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)								
	Bridger Wilderness			Teton Wilderness			Teton National Park		
Plant Site	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2	3-Hour 25	24-Hour[2] 5	Annual 2
Big Mesa	3.3	0.7 (1.2)	0.08	1.0	0.2 (0.5)	0.02	0.8	0.2 (0.6)	0.01
West Dry Basin	2.7	0.8 (1.3)	0.05	1.1	0.2 (0.5)	0.02	0.9	0.2 (0.6)	0.01
East Dry Basin	7.5	1.8 (2.7)	0.13	2.3	0.4 (1.2)	0.04	2.0	0.3 (1.3)	0.03
Buckhorn	14.6	3.0 (6.8)	0.28	3.7	0.6 (2.0)	0.07	3.1	0.6 (2.1)	0.05

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-47

INDIVIDUAL GAS TREATMENT PLANT SO_2 IMPACTS IN PROPOSED PSD CLASS I AREAS

NORTHERN ALTERNATIVE

	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)					
	Scab Creek Primitive Area			Fossil Butte National Monument		
Plant Site	3-hour 25	24-hour[2] 5	Annual 2	3-hour 25	24-hour[2] 5	Annual 2
Big Mesa	2.2	0.8 (1.3)	0.06	1.8	0.4 (0.7)	0.03
West Dry Basin	2.4	0.8 (1.4)	0.15	2.3	0.5 (1.3)	0.01
East Dry Basin	6.4	2.4 (3.5)	0.16	4.9	1.0 (2.7)	0.10
Buckhorn	16.8	4.3 (8.2)	0.37	7.6	1.4 (4.0)	0.14

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions.

TABLE 2-48

COMBINED SO_2 IMPACTS IN PSD CLASS II AREAS

NORTHERN ALTERNATIVE

Maximum SO_2 Concentrations/PSD Increments (μg/m^3)					
3-Hour		24-Hour[1]		Annual	
Concentration	Increment	Concentration	Increment	Concentration	Increment
278	512	68 (174)	91	9	20

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[1] The concentrations in parentheses are based on hypothetical "worst-case" screening conditions. Underscored concentrations are above applicable increment.

TABLE 2-49

COMBINED SO_2 IMPACTS IN EXISTING AND PROPOSED PSD CLASS I AREAS NORTHERN ALTERNATIVE

	Maximum SO_2 Concentrations/PSD Increments[1] ($\mu g/m^3$)		
	3-hour	24-hour[2]	Annual
Area	25	5	2
Bridger Wilderness (existing Class I area)	21.5	5.5[3](6.8)	0.6
Teton Wilderness (existing Class I area)	7.1	1.0 (3.4)	0.1
Teton National Park (existing Class I area)	5.6	1.0 (3.8)	0.05
Scab Creek Primitive Area (proposed Class I area)	18.8	6.5[3](11.0)	0.9
Fossil Butte National Monument (proposed Class I area)	11.8	2.4 (6.1)	0.2

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[1] The PSD increments are shown immediately beneath the time average. Concentrations underscored are above applicable increments.

[2] Concentrations in parentheses represent modeling estimates using hypothetical "worst-case" screening conditions.

[3] The listed concentrations represent maximum predicted concentrations. The highest second highest values (used to determine compliance with PSD increments) are 3.9 micrograms/cubic meter at Bridger and 4.7 micrograms/cubic meter at Scab Creek. Both values are below the 5 microgram/cubic meter PSD limit.

Notwithstanding the predicted violations of 24-hour Class I and II increments with hypothetical worst-case meteorology, it is concluded that combined SO_2 impacts for the Northern Alternative would not result in significant impacts in Class I and Class II areas. However, these results should be checked in the PSD review process with onsite meteorological data, once they are available.

The locations of the predicted maximum 24-hour SO_2 impacts in Class II areas (from Table 2-45), and in the proposed and existing Class I areas (from Table 2-49) are presented in Map 2-4. Since 24-hour average impacts are usually more limiting than 3-hour and annual impacts, the locations of the maximum 24-hour impacts are helpful in illustrating the extent of the SO_2 impacts.

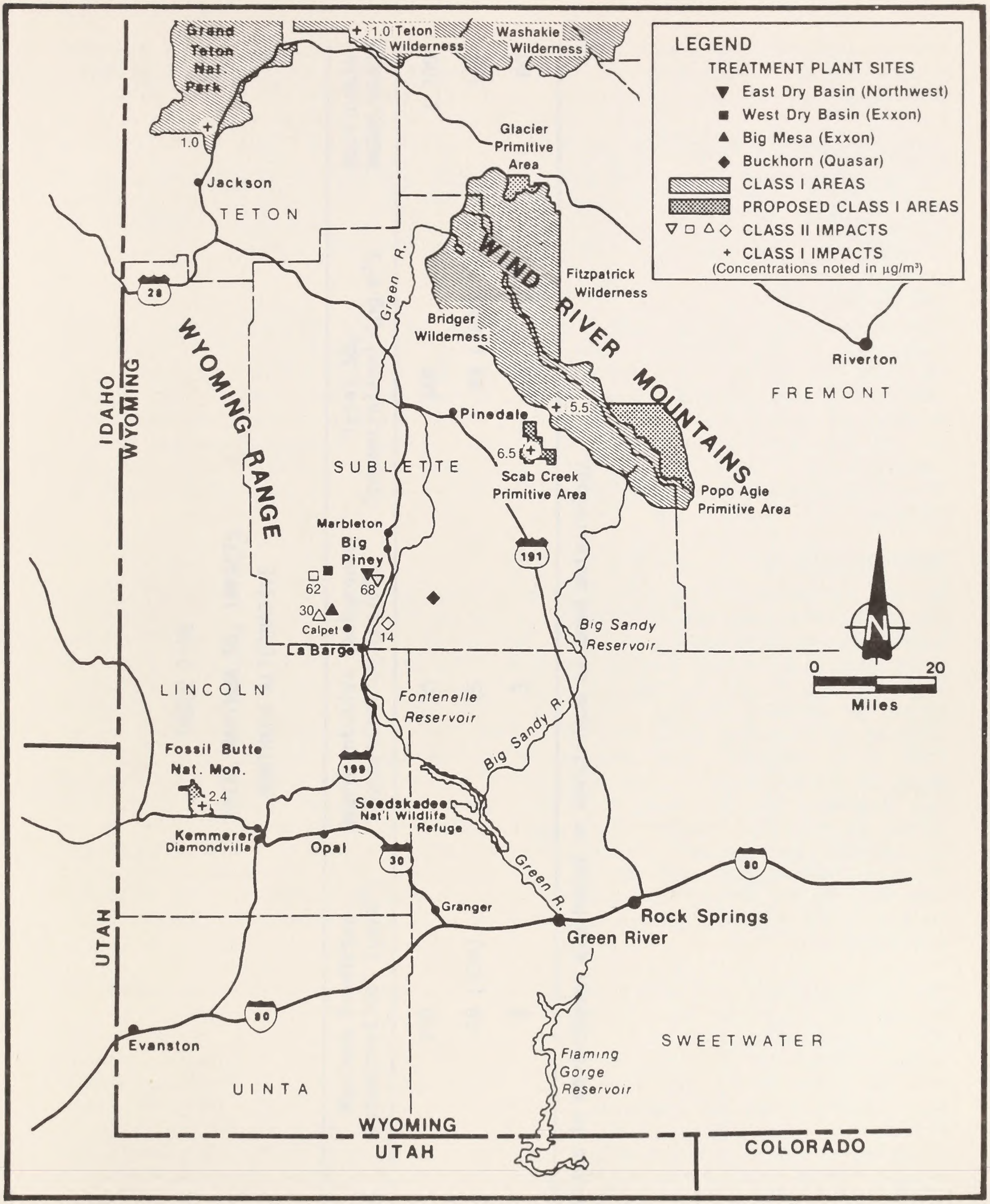
As with the Proposed Action and other alternatives, total atmospheric burdens of SO_2 due to the operation of the plants in the Northern Alternative would not cause any exceedances of the 3-hour, 24-hour, and annual NAAQS/WAAQS. Table 2-50 summarizes total SO_2 burdens and applicable NAAQS/WAAQS. When combined with representative background SO_2 concentrations of the total maximum SO_2 concentrations with actual off-site meteorological data are: 348 micrograms/cubic meter 3-hour average, 83 micrograms/cubic meter 24-hour average, and a 11 micrograms/cubic meter annual average. The maximum 24-hour SO_2 concentration with assumed worst-case meteorology is 189 micrograms/cubic meter. These predicted total SO_2 burdens are well below the applicable 3-hour, 24-hour, and annual SO_2 standards of 1,300, 365, 80 micrograms/cubic meter, respectively; therefore, insignificant impact is expected.

Similar to the Proposed Action and other alternatives, emergency flaring operations in the Northern Alternative are not expected to result in significant SO_2 impact.

Nitrogen Dioxide

At the Exxon Big Mesa facility and American Quasar's Buckhorn facility, the NO_x emissions are 28.9 and 5.9 tons/year, which are less than EPA's PSD de minimis rate of 40 tons/year. At Exxon's and American Quasar's sulfur loadout, the NO_x emissions are negligible. These emissions would have some small effect on total NO_2 concentrations in the area. However, based on the very small magnitude of the emission rates, they are not expected to cause or contribute to a violation of the annual NO_2 NAAQS/WAAQS. Therefore, impacts from the Exxon Big Mesa and American Quasar Buckhorn gas treatment plants, and the sulfur loadout are considered insignificant.

However, Northwest Pipeline plans to operate auxilliary steam boilers whose emissions (92.6 tons/year) are about twice as high as the EPA de minimis cutoff of 40 tons/year. Also, the Exxon West Dry Basin facility has NO_x emissions (49.7 tons/year) slightly greater than the 40 tons/year de minimis cutoff. The Northwest Pipeline and Exxon West Dry Basin NO_x emissions were modeled according to the procedures specified in Chapter 3 (assuming all NO_x is converted to NO_2). The modeled maximum annual average is about 3 micrograms/cubic meter at the eastern plant boundary of Northwest's facility at East Dry Basin. When added to a background value of 9 micrograms/cubic meter, the 12 micrograms/cubic meter total is well below the NAAQS/WAAQS of



MAP 2-4 LOCATIONS OF MAXIMUM 24-HOUR AVERAGE SO_2 CONCENTRATIONS IN PSD CLASS I AND CLASS II AREAS FOR THE NORTHERN ALTERNATIVE

TABLE 2-50

TOTAL MAXIMUM SO_2 IMPACTS

NORTHERN ALTERNATIVE

Time Period	Maximum Predicted Concentration[1] (μg/m³)	Representative Background Concentration (μg/m³)	Total SO_2 Concentration[1] (μg/m³)	Applicable NAAQS/WAAQS
3-Hour	278	70	348	1,300
24-Hour	68 (174)	15	83 (189)	365
Annual	8	3	11	80

[1] Concentrations in parentheses are based on worst-case assumed meteorology.

100 micrograms/cubic meter. Therefore, insignificant NO_2 impact is expected from Northwest's facility at East Dry Basin and Exxon's West Dry Basin facility.

Total Suspended Particulate

The gas treatment plants and sulfur loadout would be very small sources of particulates. Emissions from all plants and ancillary facilities would be below EPA's de minimis emission rate of 25 tons/year. Therefore, insignificant TSP impact is expected from the Proposed Action.

Carbon Monoxide

The only source of CO above the EPA de minimis emission level of 100 tons/year is the Northwest Pipeline tail gas incinerator (6,084 tons/year) at East Dry Basin. The maximum modeled 1-hour and 8-hour concentrations (including background) are 3,906 micrograms/cubic meter and 1,805 micrograms/cubic meter, respectively. These are well below the NAAQS/WAAQS of 40,000 micrograms/cubic meter and 10,000 micrograms/cubic meter, respectively. Therefore, it is concluded that operation of the gas treatment plants in the Northern Alternative would not cause significant CO impacts.

Hydrogen Sulfide

Except for Northwest at East Dry Basin, the results for the Proposed Action and other Alternatives also apply to the Northern Alternative. Table 2-51 summarizes maximum impacts for the Northern Alternative. H_2S concentrations from Exxon's plants at Big Mesa and West Dry Basin, and Northwest's plant at East Dry Basin are 7, 12, and 9 micrograms per cubic meter, respectively; below the Wyoming one-half hour H_2S standards of 70 micrograms/cubic meter (not to be exceeded more than twice per year) and 40 micrograms/cubic meter (not to be exceeded more than twice in five days). The American Quasar's plant at Buckhorn would likely cause violations of the one-half hour Wyoming H_2S standard of 40 micrograms/cubic meter (not to be exceeded more than twice in any five consecutive days). The predicted maximum value is 65 micrograms/cubic meter. Therefore, only the Buckhorn facility is expected to cause significant H_2S impacts. These conclusions should be verified in the PSD review process by remodeling with representative on-site meteorological data and more precise engineering plot plans once the information is available.

The H_2S emissions in the Northern Alternative were also modeled to determine if maximum 1/2-hour concentrations could exceed the odor threshold of 6.5 micrograms/cubic meter in Big Piney, LaBarge, and Marbleton. These are the towns closest to the proposed gas treatment plant sites. The model results for the Exxon facilities at West Dry Basin and Big Mesa indicate H_2S odors may potentially be detectable only in isolated high terrain areas surrounding each 600 million SCFD facility. The high terrain significantly impacted is about 3 kilometers to the west-southwest of West Dry Basin and about 4 kilometers to the southwest of Big Mesa. However, concentrations in Big Piney, LaBarge, and Marbleton are expected to be below the significance criterion (maximum H_2S concentration is 0.2 micrograms/cubic meter in Big Piney). Maximum concentrations in all proposed and existing PSD Class I areas are expected to be negligible from Exxon's facilities at Big Mesa and West Dry Basin.

TABLE 2-51

MAXIMUM MODELED H_2S
NORTHERN ALTERNATIVE

Plant Site	Capacity (Million SCFD)	Company	½-Hour H_2S Concentrations[1]/WAAQS[2] ($\mu g/m^3$)	
			40, 70	40, 70
West Dry Basin	600	Exxon	12	(9)
Big Mesa	600	Exxon	7	(5)
Buckhorn	1,200	American Quasar	65	(57)
East Dry Basin	400	Northwest Pipeline	9	(7)

[1] These concentrations were evaluated at the plant boundary and beyond because the H_2S WAAQS do not apply within plant property. Concentrations in parentheses are based on hypothetical "worst-case" meteorology. Concentrations for actual off-site meteorology are higher than with "worst-case" assumed meteorology because the "worst-case" assumed meteorology is "F" stability and 2.5 meters/second wind speed (typical assumption by EPA Region VIII and WDEQ, whereas the actual off-site meteorological data contains several hourly occurrences of "F" stability and wind speeds lower than 2.5 meters/second. The lower wind speed results in less plume dilution and consequently higher ½-hour H_2S concentrations.

[2] The WAAQS are shown immediately beneath the column heading. Concentrations underscored exceed one or both of the WAAQS. The 40 micrograms/cubic meter-limit is not to be exceeded more than twice in any five consecutive days and the 70 micrograms/cubic meter limit is not to be exceeded more than twice in any year.

The American Quasar significant odor impacts are predicted to occur out to about 6 kilometers of the stacks at the Buckhorn site in all directions. Maximum concentrations of H_2S are not expected to exceed the significance criterion in any nearby towns (maximum H_2S concentrations is 3.8 micrograms/cubic meter in Big Piney). Concentrations in all proposed and existing Class I areas are expected to be negligible.

Hydrogen sulfide from the Northwest Pipeline could exceed the odor significance criterion of 6.5 micrograms/cubic meter in isloated high terrain areas about 1 kilometer to the southeast of the East Dry Basin site. However, in Big Piney, the nearest town, the maximum H_2S is predicted to be 0.3 micrograms/cubic meter. Maximum H_2S levels in all proposed and existing Class I areas are expected to be negligible.

Because of individual differences to odor sensitivity some people may be able to detect odors at distances greater than predicted in this analysis.

Carbonyl Sulfide

Except for Northwest at East Dry Basin, the maximum modeled COS impacts of the Proposed Action and Buckhorn Alternative also apply to the Northern Alternative. Table 2-52 summarizes maximum COS concentrations. The maximum annual COS concentrations are: Exxon at West Dry Basin-5 micrograms/cubic meter; Exxon at Big Mesa-3 micrograms/cubic meter; American Quasar's plant at Buckhorn-10 micrograms/cubic meter; and Northwest Pipeline's facility at East Dry Basin-0.07 micrograms/cubic meter.

The maximum 8-hour average COS concentrations are: Exxon at Big Mesa-75 micrograms/cubic meter; Exxon at West Dry Basin-225 micrograms/ cubic meter; American Quasar's plant at Buckhorn-83 micrograms/cubic meter; and Northwest Pipeline's facility at East Dry Basin-2 micrograms/cubic meter.

Based on the significance criteria of 800 micrograms/cubic meter (annual average) and 60,000 micrograms/cubic meter (8-hour average), no significant COS impact is expected from Exxon's facilities at West Dry Basin and Big Mesa, the American Quasar facility at Buckhorn, or the Northwest facility at East Dry Basin.

Annual average COS concentrations from all facilities emissions combined were also evaluated. The highest concentration, 10 micrograms/cubic meter, is well below the significance criterion of 800 micrograms/cubic meter. Therefore, insignificant COS impact is expected in all urban areas for the Northern Alternative.

Carbon Dioxide

Emissions of CO_2 are not expected to cause a general climatic warming, although considerable uncertainity exists regarding the potential for the "greenhouse effect". The conclusions regarding predicted annual average CO_2 impacts (except for Northwest at East Dry Basin) for the other alternatives also represent the Northern Alternative. The CO_2 emissions from the American Quasar facility at Buckhorn would result in a CO_2 concentration of 0.2 grams/cubic meter which is below the 11 gram/cubic meter significance criterion. The Exxon impacts at West Dry Basin and Big Mesa are 0.02 and 0.01 grams/cubic meter, respectively. The Northwest facility at East Dry

TABLE 2-52

MAXIMUM MODELED COS CONCENTRATIONS
NORTHERN ALTERNATIVE

Plant Site	Annual Average COS Concentrations/MEG[1] ($\mu g/m^3$) 800
West Dry Basin (Exxon)	5
Big Mesa (Exxon)	3
East Dry Basin (Northwest Pipeline)	10
Buckhorn (American Quasar)	0.07

Plant Site	8-Hour Average COS Concentrations/Toxicity Value[2] ($\mu g/m^3$) 60,000
West Dry Basin (Exxon)	225
Big Mesa (Exxon)	75
Buckhorn (American Quasar)	83
East Dry Basin (Northwest Pipeline)	2

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[1] The MEG stands for EPA's multi media environmental goal. Its value is shown immediately beneath the column heading.

[2] The toxicity value is shown immediately beneath the column heading.

Basin would result in CO_2 impacts of 0.08 grams/cubic meter. Therefore, insignificant CO_2 impacts are expected.

Helium

The conclusions in the Proposed Action and other alternatives also apply to the Northern Alternative, i.e., no significant impact because He concentrations would be everywhere less than the 30,000 parts/million required to cause asphyxiation.

ACID DEPOSITION IN PSD CLASS I AREAS

The potential acute changes to water chemistry in the Bridger Wilderness resulting from the Northern Alternative are presented in Table 2-53. The largest decreases in lake pH (0.10 to 0.20 pH) are predicted to occur at Clear Lake (South). Decreases at Hobbs Lake and Clear Lake (North) are predicted to be less than or equal to 0.05 pH. Resulting pH values are not expected to drop below 6.25, still within tolerable limits for fish populations and habitat. Therefore insignificant impacts are expected. Long-term pH changes have not been assessed due to a lack of data. Additional data measurement recommendations are given in the discussion of the Proposed Action.

VISIBILITY IMPAIRMENT IN PSD CLASS I AREAS

At the Bridger Wilderness and at Scab Creek Primitive Area, visibility impairment from the Northern Alternative would be slightly greater than that for the Proposed Action because the American Quasar plant and Northwest's facility would be closer to these areas. However, EPA Level 1 calculations show that all three indices of potential impairment would still be below the critical value of 0.1. Therefore, significant visibility impairment is not likely in any of the existing or proposed Class I areas.

IMPACTS TO VEGETATION AND SOILS IN PSD CLASS I AREAS

No significant impact is expected in Class I areas to sensitive vegetation, i.e., lichens, from the Northern Alternative because it is expected that applicable PSD increments for SO_2 and TSP would be met.

SECONDARY GROWTH IMPACTS

The town-by-town population increases for the Northern Alternative are shown in Table 2-54. Table 2-55 displays the maximum modeled concentrations (which include background) and NAAQS/WAAQS. These total pollutant burdens are very low in relation to the standards and would not result in violations of the NAAQS/WAAQS for TSP, SO_2, CO, HC, or NO_x.

AIR QUALITY RELATED VALUES IMPACTS

As discussed above, impacts to the AQRV flora odor, visibility, (due directly from SO_2 and particulate) and acid deposition effects on trout (due directly from pH changes) in sensitive high altitude lakes are expected to be insignificant. However, it is unknown whether impacts to the other AQRV, i.e., flora (for example from acid deposition), fauna (other than sensitive fish), water, soil, cultural/archeological, and geologic would be significant.

TABLE 2-53

ESTIMATED EFFECTS ON WATER CHEMISTRY OF THREE LAKES IN THE BRIDGER WILDERNESS, NORTHERN ALTERNATIVE

	Clear Lake (North)	Hobbs Lake	Clear Lake (South)
Baseline pH	6.60	6.50	6.45
Measured Alkalinity (eq/l x 10^{-6})	110.0	112.0	85.0
Calculated Alkalinity (eq/l x 10^{-6})	19.95	15.85	14.13
Incremental H^+ Input (eq/l x 10^{-6})	0.26 - 0.51	0.70 - 1.39	2.44 - 4.87
Remaining Alkalinity (eq/l x 10^{-6})	19.69 - 19.44	15.15 - 14.46	11.69 - 9.26
Resulting pH	6.59 - 6.59	6.49 - 6.46	6.37 - 6.27
ΔpH	0.01	0.01 - 0.04	0.08 - 0.18
After accounting for the potential effect of the freezing point depression of acidic snow:			
Resulting pH	6.55 - 6.55	6.49 - 6.46	6.37 - 6.27
ΔpH	0.05	0.01 - 0.04	0.08 - 0.18
After accounting for the potential effect of plant flaring:			
Resulting pH	6.55 - 6.55	6.49 - 6.46	6.35 - 6.25
ΔpH	0.05	0.01 - 0.04	0.10 - 0.20

TABLE 2-54

MAXIMUM ESTIMATED POPULATION INCREASE FROM RILEY RIDGE PROJECT NORTHERN ALTERNATIVE

County	Community	Population Increase	Year
Lincoln	Afton	19	1986
	Cokeville	55	1986
	Diamondville	643	1985
	Kemmerer	1,220	1985
	LaBarge	1,670	1986
	Thayne	7	1985
Sublette	Big Piney	1,138	1986
	Marbleton	1,048	1986
	Pinedale	209	1986
Sweetwater	Granger	73	1985
	Green River	416	1985
	Rock Springs	368	1985
	South Superior	28	1985
	Wamsutter	14	1985

TABLE 2-55

AIR QUALITY IMPACT OF SECONDARY GROWTH ON THE BIG PINEY-MARBLETON AREA NORTHERN ALTERNATIVE

Pollutant	Total Maximum Concentrations/NAAQS/WAAQS ($\mu g/m^3$)									
	1-Hour		3-Hour		8-Hour		24-Hour		Annual	
	Conc.	Std	Conc	Std	Conc	Std	Conc	Std	Conc	Std
TSP	--	--	--	--	--	--	61.5[5]	150	30.4[7]	60
SO_2	--	--	70.2[2]	1,300	--	--	15.1[6]	365	3.02[8]	80
NO_x	--	--	--	--	--	--	--	--	9.2[9]	100
CO	3,577[1]	40,000	--	--	1,558[4]	10,000	--	--	--	--
HC	--	--	5.2[3]	160	--	--	--	--	--	--

[1] Includes a background concentration of 3,500 micrograms/cubic meter.

[2] Includes a background concentration of 70 micrograms/cubic meter.

[3] Does not include a background concentration. Background is unknown but is expected to be low.

[4] Includes a background concentration of 1,500 micrograms/cubic meter.

[5] Includes a background concentration of 60 micrograms/cubic meter.

[6] Includes a background concentration of 15 micrograms/cubic meter.

[7] Includes a background concentration of 30 micrograms/cubic meter.

[8] Includes a background concentration of 3 micrograms/cubic meter.

[9] Includes a background concentration of 9 micrograms/cubic meter.

SUMMARY OF THE NORTHERN ALTERNATIVE OPERATIONS-RELATED IMPACTS

Operation of the Northern Alternative is expected to result in insignificant air quality impacts except for the following:

1) The maximum H_2S concentrations from American Quasar's plant at Buckhorn do not exceed the 70 microgram/cubic meter standard but they do exceed the one-half hour 40 microgram/cubic meter standard more than twice in any five consecutive days. The maximum one-half hour H_2S concentrations for each gas treatment plant using actual, off-site meteorological data (and assumed worst-case meteorology) are: 65 (57) micrograms/cubic meter. Significant odor impacts are also expected in all directions out to distances of about 6 kilometers from the Buckhorn facility. Significant odor impacts are also expected in localized high terrain areas around the Exxon West Dry Basin and Big Mesa plants and around Northwest's East Dry Basin plant because the maximum predicted H_2S concentrations from these facilities are 12, 7 and 9 micrograms/cubic meter, respectively, which exceed the odor significance criterion of 6.5 micrograms/cubic meter.

SUMMARY OF ALL SIGNIFICANT IMPACTS

Table 2-56 summarizes the maximum SO_2 concentrations for the well drilling operations and the various plant siting alternatives. Maximum concentrations are also compared to appropriate NAAQS/WAAQS and PSD Class I and II increments. Concentrations above significance criteria are underscored. Although maximum 24-hour SO_2 concentrations in PSD Class I areas for the Buckhorn, Shute Creek, and Northern Alternative are above the Class I increment of 5 micrograms/cubic meter, significant impacts are not expected because the predicted highest second-highest values, as explained in previous sections, are below that significance criterion. The only significant SO_2 impact is predicted for the Proposed Action.

Table 2-57 summarizes the maximum concentrations for all other pollutants besides SO_2 as well as impacts predicted from acid deposition and visibility impairment. Note that significant impacts are predicted for the Proposed Action and all alternatives for H_2S (and its odor).

The results of this study indicate that significant air quality impacts are not expected from emissions generated by the various Riley Ridge Project construction activities including NO_2 impacts from well drilling operations. (The more refined modeling analysis utilizing ambient O_3 data showed lower NO_2 impacts).

Well field operations are expected to cause insignificant impacts. However, potentially significant impacts could result from emissions during operation of the gas treatment plants. Sulfur dioxide emissions from American Quasar's 1.2-billion SCFD facility at East Dry Basin would probably exceed the PSD Class II 24-hour increment of 91 micrograms/cubic meter several times per year.

Venting of CO_2 and nitrogen offgases could also result in potentially significant H_2S impacts. The H_2S in these offgases from the American Quasar

TABLE 2-56

SUMMARY OF TOTAL MAXIMUM SO_2 CONCENTRATIONS[1] FROM CONSTRUCTION AND OPERATING ACTIVITIES

Type of Criterion	Criterion	Averaging Time	Proposed Action Max Conc	Proposed Action Percent Criterion	Buckhorn Alternative Max Conc	Buckhorn Alternative Percent Criterion	Shute Creek Alternative Max Conc	Shute Creek Alternative Percent Criterion	Northern Alternative Max Conc	Northern Alternative Percent Criterion
NAAQS/WAAQS[2]	80	Annual	21	26	21	26	21	26	21	26
NAAQS/WAAQS[3]	80	Annual	18	23	10	13	12	15	11	14
	365	24-Hour	139	38	77	21	67	18	83	23
	1,300	3-Hour	564	43	348	27	277	21	348	27
PSD Class II[3]	20	Annual	15	75	8	40	9	45	9	45
	91	24-Hour	124	136	62	68	52	57	68	75
	512	3-Hour	494	96	278	54	207	40	278	54
PSD Class I[3]	2	Annual	0.7	35	0.7	35	0.4	20	0.9	45
	5	24-Hour	4.7	94	5.9[4]	118	5.3[4]	106	6.5[4]	130
	25	3-Hour	16.6	66	19.5	78	20.4	82	21.5	86

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[1] All concentrations are based on modeling with actual offsite meteorological data. All numbers shown are micrograms/cubic meter. Concentrations underscored are above applicable significance criteria.

[2] From well drilling operations.

[3] From operation of the gas treatment plants.

[4] Even though the maximum concentration exceeds the significance criteria, the highest second highest concentration does not, so these impacts are not considered significant. The highest second highest values for the Buckhorn, Shute Creek, and Northern Alternatives are 4.3, 4.3, and 4.7 micrograms/cubic meter, respectively.

TABLE 2-57

SUMMARY OF TOTAL MAXIMUM CONCENTRATIONS[1]/IMPACTS FROM CONSTRUCTION AND OPERATING ACTIVITIES

Pollutant/ Impact	Type of Significance Criterion	Significance Criterion	Averaging Time	Proposed Action		Buckhorn Alternative		Shute Creek Alternative		Northern Alternative	
				Max Conc	Percent Criterion	Max Conc	Percent Criterion	Max Conc	Percent Criterion	Max Conc	Percent Criterion
NO_2[2]	NAAQS/WAAQS	100	Annual	66	66	66	66	66	66	66	66
NO_2[3]	NAAQS/WAAQS	100	Annual	10	10	10	10	11	11	12	12
TSP[2]	NAAQS/WAAQS	60	Annual	48	80	48	80	48	80	48	80
TSP[4]	NAAQS/WAAQS	60	Annual	47	78	47	78	47	78	47	78
H_2S[3]	WAAQS	40	Half-hour	237	593	65	163	65	163	65	163
H_2S	Odor	6.5	Instantaneous	HT[6]	N/A	6 km	N/A	6 km	N/A	6 km	N/A
COS[3]	MEG	800	Annual	19	2	10	1	10	1	10	1
COS[3]	Toxicological	60,000	8-Hour	623	1	225	<1	91	<1	225	<1
CO_2[3]	TLV	11g/m^3	Annual	0.5	5	0.2	2	0.2	2	0.2	2
CO[3]	NAAQS/WAAQS	40,000	1-Hour	3,906	10	3,906	10	3,906	10	3,906	10
CO[3]	NAAQS/WAAQS	10,000	8-Hour	1,805	18	1,805	18	1,805	18	1,805	18
He	Asphyxiant	30,000 ppm	Instantaneous	<30,000 ppm	N/A	<30,000 ppm	N/A	<30,000 ppm	N/A	<30,000 ppm	N/A
Acid Deposition	Lake Acidity	<6.0 pH	Short term	6.28 pH	N/A	6.28 pH	N/A	6.32 pH	N/A	6.25 pH	N/A
Visibility Impairment	Aesthetic	>0.1[5]	Short term	<0.1[5]	N/A	<0.1[5]	N/A	<0.1[5]	N/A	<0.1[5]	N/A

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[1] All concentrations are based on modeling with actual offsite meteorological data. All numbers shown are micrograms/cubic meter unless otherwise noted. Underscored values are above applicable significance criteria.

[2] From well drilling operations.

[3] From operation of the gas treatment plants.

[4] From construction activities.

[5] Dimensionless.

[6] The significance criterion is exceeded in high terrain areas surrounding the Big Mesa, West Dry Basin, and East Dry Basin facilities.

treatment plant, regardless of location, would probably exceed the Wyoming ½-hour ambient standard of 40 micrograms/cubic meter more frequently than allowable. Significant odor impacts are also expected from H_2S emissions at American Quasar's facility, whether it is sited at East Dry Basin or Buckhorn. Significant odor impacts are also expected in isolated high terrain areas around the Exxon Big Mesa, West Dry Basin, and East Dry Basin facilities, as well as around the Northwest East Dry Basin facility.

The SO_2 emissions modeled from the Northwest facility represent 99.4 percent sulfur control. Exxon anticipates a total 99.8 percent sulfur removal efficiency and American Quasar anticipates a 99.6 percent removal efficiency. Higher levels of sulfur removal could be achieved at the Northwest Pipeline facility by using other control technologies. If Northwest achieved the level of control at the other plants, the result would be a decrease in SO_2 emissions and impacts accordingly. However, stated above, significant SO_2 impacts are not expected from the Northwest Pipeline 400 million SCFD facility at the 99.4 percent sulfur control level, whether it is sited at Craven Creek or East Dry Basin.

It should be emphasized that the significant short-term SO_2 and H_2S impacts discussed above are considered best available estimates because the dispersion modeling used to estimate concentrations was based on offsite meteorological data. These results should be checked in the PSD review process with a set(s) of representative onsite meteorological data, once the data are available.

CHAPTER 3

METHODOLOGY

INTRODUCTION

This chapter describes the data, assumptions, techniques, and modeling procedures used to quantify the air resource impacts from direct and indirect Riley Ridge Project emissions. Chapter 3 is subdivided into seven major subsections as follows:

Emissions Inventory Development,
Dispersion Meteorology Data Development,
Modeling of Operations-Related Primary Pollutants,
Secondary Growth Modeling,
Visibility Impairment Modeling,
Acid Deposition Modeling, and
Modeling of Construction-Related Impacts

EMISSIONS INVENTORY DEVELOPMENT

Exxon Company, U.S.A. (Exxon) proposes to develop (over about 40 years) its sour low-Btu natural gas reserves from a deep gas field in Sublette County, Wyoming. The proposed activities include well drilling and field production of gas; wellhead gas dehydration; sour gas collection and pipeline transmission; gas treatment plants; by-product transport systems; access roads; and related ancillary facilities.

Northwest Pipeline Corporation (Northwest) and Mobil Oil Corporation (Mobil) propose to develop sour, low-Btu natural gas reserves from a deep gas field in Sublette County, Wyoming. Mobil has lease holdings in the gas field and would develop the field and produce the gas. Northwest proposes to construct and operate sour gas collection and pipeline transmission facilities from Mobil's producing well field, as well as a gas treatment plant, sales gas pipelines, and related ancillary facilities. The gas treatment plant is to be located in Lincoln County.

American Quasar Petroleum Company (Quasar) and Williams Exploration Company (Williams) propose to develop sour, low-Btu natural gas reserves from a new deep gas field in Sublette County, Wyoming. The Quasar and Williams project includes well drilling and field production of gas; sour gas collection and transport via pipelines; one gas treatment plant; by-product transportation systems; access roads; and ancillary facilities.

The following three subsections contain, on a company-by-company basis, more detailed process descriptions of those unit operations which are significant sources of air emissions. These subsections are divided by well field alternatives, plant alternatives, product distribution systems, and construction-related emissions. The fourth subsection of the Riley Ridge

Project emissions inventory summarizes those emissions associated with direct and indirect population growth in the towns expected to experience the bulk of the growth.

OPERATION OF WELL FIELDS, PLANTS, AND PIPELINES

Well Field Operations

Exxon Facilities

Exxon proposes to develop as many as 75 gas wells, each producing at nominally 20 million standard cubic feet per day (SCFD), over the life of the project. Well field emissions would result primarily from initial well drilling, which employs diesel-fired drilling rigs. Up to six drilling rigs (one per well site) would be in Exxon's well field at any given time over the first 10-15 years of the project. Each rig would operate approximately 230 days at each site. The diesel generators emit SO_2, NO_x, CO, TSP, and VOC. Very minor VOC losses would also occur from diesel fuel storage tanks at the wellhead sites.

Well completion and testing follows the drilling operation which takes approximately three days per well. Combustion-related emissions would result from the short-term firing of natural gas heaters (which heat the gas prior to separation during testing), and from flaring of the well gas during testing.

As the gas reservoir is depleted, the wellhead pressure would decline below the minimum operating pressure of about 1,440 pounds/square inch and eventually gas compression would be required. At that time, electrically driven compressors would be installed downstream to maintain adequate supply pressure at the gas treatment plant.

Moist sour gas is very corrosive to pipelines. Therefore, dehydration at or near the well sites would be provided to minimize corrosion in the gas gathering and delivery system. The dehydration systems would be sized to process various multiples of 20 million SCFD. Where feasible, larger dehydration units would be provided to serve up to three or four wells, thus reducing the number of surface facilities and associated land requirements at each well site. During infrequent upset conditions that lead to failure of the TEG dehydration systems, flaring of the sour gas for short time periods would produce large SO_2 emissions.

Mobil/Northwest Facilities

Mobil would develop the well field and produce the sour gas to be sent to Northwest's gas treatment plant. The well field would include a total of 67 wells, 4 of which are completed. Mobil would also use diesel-fired drilling equipment, and one drilling rig would operate in the well field at any given time for about 230 days at each site. Diesel fuel would be stored at each well site. Along with short-term flaring of gas at the wellhead during initial testing, there would be NO_x emissions from 10 relatively small wellhead heaters at each site once the wells are in production. Flare facilities at each wellhead would be included for upset conditions which would emit SO_2.

Flares would also be operated about once every 18 days at each well head to purge dehydration vessels. Each flaring operation would last about one-half hour. There would be a total of about 20 wells operating at any one time.

Quasar and Williams Facilities

A total of 72 gas producing wells are planned by Quasar and 24 wells by Williams to supply nominally 1.2 billion SCFD of sour gas to the gas treatment plant. A maximum of six drilling rigs are expected to operate by Quasar in the well field at any given time (about 230 days per site) until well field development is completed in 1990. Williams anticipates up to two active rigs at any one time. Each well would produce gas at about 1500 pounds/square inch for about 22 years, and until this pressure diminishes no compressors would be needed in the field.

Unlike Exxon's and Mobil's wellhead facilities, no field dehydration system is planned by Quasar. The trunk lines would be designed to carry all water and gas to the gas treatment plant for dehydration. Additional facilities at Quasar's production well sites include gas heaters and a flare for initial well start-up/testing, and diesel fuel storage. Williams does plan well site dehydration which may require some small natural gas-fired heaters similar to those proposed by Mobil.

Well Field Emissions

The well field activities described above would result in significant quantities of air pollutant emissions. The emissions inventory is dominated by well drilling activities rather than operations-related activities. Tables 3-1 through 3-6 contain the emission rates from well field drilling and operations activities for Exxon, Mobil/Northwest, and American Quasar, respectively. For each company, two tables are provided; the first contains short-term emissions rates and stack parameters, and the second table lists annual average emissions. Of the well field activities, combustion products from the diesel-fired generators dominate the NO_x, CO, VOC, and particulate emissions. SO_2 emissions result primarily from flaring during testing and, at Exxon's facilities, from dehydration unit upsets.

The emission rates in Tables 3-1 through 3-6 are based on emission factors and operating parameters provided by the applicants and verified by ERT. The emission factors are based largely on generic factors published in EPA (1977) publication AP-42 entitled Compilation of Air Pollution Emission Factors.

Gas Treatment Plant and Ancillary Facilities Operations

Sour gas from the Riley Ridge wells contains undesirable amounts of hydrogen sulfide, carbon dioxide, nitrogen, helium, water, and other reduced sulfur species. The unit operations typically included in the gas treatment plants are acid gas removal, desulfurization with sulfur recovery, final dehydration, and cryogenic separation of residual inerts such as nitrogen and helium. Various techniques exist for performing these required operations; the specific processes employed by each company are described below.

TABLE 3-1

RILEY RIDGE PROJECT EMISSIONS INVENTORY

EXXON CORPORATION

Source Description	Emission Rate (g/s)								Emission Frequency		Stack Parameters			
	CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC	Hrs/Day	Days/Yr	Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temp (°K)
Gas Processing Plant (Emission rates represent one plant at 600 million scfd capacity. Two 600 million scfd plants are proposed.)														
Selexol CO_2/N_2 Vent	--	59.4	207,284	1.09	--	--	--	--	24	365	53.9	2.74	27.13	421.9
SCOT Tail Gas Incinerator	--	--	37,150	--	--	43.47	--	--	24	365	61.0	1.52	24.38	505.4
Start-up Steam Boilers	0.13	--	871	--	1.69	0.01	0.11	0.02	24	110	15.2	0.88	21.34	477.6
Start-up Plant Flare	--	--	--	--	--	2,245	--	--	11	9	61.0	1.52	21.34	97.76
Regeneration Gas Heater	0.02	--	93	--	0.09	0.0004	0.01	--	24	365	6.1	0.08	15.24	672.1
Emergency Plant Flare						7,967^1			0.5	12				
	--	--	--	--	--	23,922^2	--	--	1.0	1	61.0	1.52	42.67	977.6
Emergency Gen. at Big Mesa	1.84	--	--	--	8.56	0.58	0.60	0.81	24	10	Not Available			
Emergency Gen. at West Dry Basin	11.3	--	--	--	52.2	3.53	3.78	4.91	24	10	Not Available			
Diesel Fuel Storage	--	--	--	--	--	--	--	0.001	24	365	Not Applicable			
Molten Sulfur Storage	--	--	--	--	--	--	0.01	--	24	365	Not Applicable			
Well Field Sites (Emission rates represent those occurring at each well site, except for dehydration units.)														
Diesel Fixed Generators	1.72	--	--	--	7.98	0.53	0.59	0.74	24	230^3	3.05	0.15	24.38	810.9
Diesel Fuel Storage	--	--	--	--	--	--	--	0.0004	24	365	Not Applicable			

TABLE 3-1 (CONTINUED)

Source Description	Emission Rate (g/s) CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC	Emission Frequency Hrs/Day	Day/Yr	Stack Parameters Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temp (°K)
Wellhead Flare (Well Testing)	--	--	--	--	--	16.6	--	--	24	3	25.6	0.25	60.96	977.6
Gas Heaters (Well Testing)	0.005	--	--	--	0.32	0.001	0.04	0.02	24	3	15.2	0.76	30.48	810.9
Dehydration Units Flaring Systems (Emission rates represent the number of units for each capacity specified below.)														
Unit Capacity / No. Units														
20 mmscfd 2	--	--	21,234	--	--	1,588	--	--	0.5	1	22.9	0.46	53.34	922.1
40 5	--	--	106,168	--	--	7,938	--	--	0.5	1	22.9	0.46	53.34	922.1
60 10	--	--	318,503	--	--	23,814	--	--	0.5	1	22.9	0.46	53.34	922.1
80 3	--	--	127,401	--	--	9,526	--	--	0.5	1	22.9	0.46	53.34	922.1
100 3	--	--	159,251	--	--	11,907	--	--	0.5	1	22.9	0.46	53.34	922.1
120 1	--	--	63,701	--	--	4,763	--	--	0.5	1	22.9	0.46	53.34	922.1
Sulfur Loadout (Emission rates represent 1.2 billion scfd capacity)														
Steam Boiler	0.003	--	20.4	--	0.038	0.0001	0.003	0.0005	24	365	18.3	0.08	18.29	477.6
Emergency Gen. at Sulfur Loadout	9.2	--	--	--	42.8	2.77	3.02	4.03	24	10	Not Available			

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[1] The flaring of one 200-million scfd module.

[2] The flaring of one 600-million scfd plant.

[3] Exxon's directional drilling alternative requires about 292 days of diesel-fired generation per site.

TABLE 3-2

RILEY RIDGE PROJECT ANNUAL EMISSIONS (TONS/YEAR)

EXXON CORPORATION

Source Description	CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC
Gas Treatment Plant (Emission rates represent one plant at 600 million scfd capacity. Two 600 million scfd plants are proposed.)								
Selexol CO_2/N_2 Vent	--	2,063	7.2×10^6	37.8	--	--	--	--
SCOT Tail Gas Incinerator	--	--	1.29×10^6	--	--	1,510	--	--
Start-up Steam Boilers	1.4	--	9,117	--	17.7	0.1	1.2	0.2
Start-up Plant Flare	--	--	--	--	--	882	--	--
Regeneration Gas Heater	0.5	--	3,230	--	3.1	0.0	0.3	--
Emergency Plant Flare	--	--	--	--	--	284.5	--	--
Emergency Gen. at Big Mesa	1.8	--	--	--	8.1	0.6	0.6	0.8
Emergency Gen. at West Dry Basin	10.8	--	--	--	49.7	3.4	3.6	4.7
Diesel Fuel Storage	--	--	--	--	--	--	--	0.03
Molten Sulfur Storage	--	--	--	--	--	--	0.3	--
Well Field Sites (Emission rates represent those occurring at each well site, except for dehydration units.)								
Diesel Fired Generators	37.7	--	--	--	174.8	11.5	12.9	16.1
Diesel Fuel Storage	--	--	--	--	--	--	--	0.08
Wellhead Flare (Well Testing)	--	--	--	--	--	4.7	--	--
Gas Heaters (Well Testing)	0.02	--	--	--	0.09	0.0004	0.01	0.01

TABLE 3-2 (CONTINUED)

Source Description		CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC
Dehydration Units Flaring Systems (Upsets): (Emission rates represent the number of units for each capacity specified below.)									
Unit Capacity	No. Units								
20 mmscfd	2	--	--	42.1	--	--	3.2	--	--
40	5	--	--	210.6	--	--	15.8	--	--
60	10	--	--	632.0	--	--	47.2	--	--
80	3	--	--	252.8	--	--	18.9	--	--
100	3	--	--	316.0	--	--	23.6	--	--
120	1	--	--	126.4	--	--	9.4	--	--
Sulfur Loadout (Emission rates represent 1.2 Billion scfd capacity)									
Steam Boiler		0.11	--	710	--	1.3	0.004	0.09	0.02
Emergency Gen. at Sulfur Loadout		8.8	--	--	--	40.8	2.6	2.9	3.8

TABLE 3-3

RILEY RIDGE PROJECT EMISSIONS INVENTORY

NORTHWEST PIPELINE CORPORATION AND MOBIL OIL CORPORATION

Source Description	Emission Rate (g/s)								Emission Frequency		Stack Parameters			
	CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC	Hrs/Day	Days/Yr	Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temp (°K)
Gas Treatment Plant (Emission rates represent one plant at 400 million scfd.)														
Selexol CO_2 Vent	--	1.51	156,240	1.52	--	--	--	--	24	365	53.9	2.74	27.13	421.9
CBA Tail Gas Incinerator	175.0	--	2,480	--	--	96.1	--	--	24	365	53.3	1.83	22.65	599.3
Steam Boilers	0.29	--	1,945	--	2.37	0.01	0.26	0.05	24	365	18.3	1.22	8.11	533.2
Emergency Plant Flare[1]	--	--	--	--	--	15,977	--	--	0.5	4	61.0	1.52	85.34	977.6
Dehydration Unit Regeneration Heaters	0.01	--	98.53	--	0.20	0.0005	0.01	0.003	12	365	18.3	0.81	2.68	477.6
Plantwide Fugitive Hydrocarbons	--	--	--	--	--	--	--	0.25	24	365		Not Applicable		
Emergency Power Generator	1.13	--	--	--	5.2	0.35	0.38	0.50	24	10	3.0	0.15	24.38	810.9
Misc. Plant Heaters	--	--	--	--	0.09	--	--	--	24	180	6.1	0.08	30.48	810.9
Methanol Storage	--	--	--	--	--	--	--	0.004	24	365		Not Applicable		
Well Field Sites (Emission rates represent those occurring at each well site.)														
Diesel Fired Drilling	2.27	--	--	--	10.50	0.70	0.70	1.00	24	230	2.9	0.20	86.26	630.4
Diesel Fuel Storage	--	--	--	--	--	--	--	0.001	24	365		Not Applicable		
Wellhead Flare (Well Testing)	--	--	--	--	--	82.91	--	--	24	3	9.1	0.15	211.84	810.9
Wellhead Heaters	0.003	--	--	--	0.02	0.0001	0.002	0.001	24	365	2.4	0.25	30.48	810.9
Wellhead Flare (Dehydration Units)	--	--	--	--	--	227	--	--	0.5	20	30.5	0.46	11.74	922

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[1] The flaring of the entire 400-million scfd plant.

TABLE 3-4

RILEY RIDGE PROJECT ANNUAL EMISSIONS (TONS/YEAR) NORTHWEST PIPELINE CORPORATION AND MOBIL OIL CORPORATION

Source Description	CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC
Gas Treatment Plant (Emission rates represent one plant at 400 million scfd.)								
Selexol CO_2 Vent	--	52	5.431×10^6	52.9	--	--	--	--
N_2 Vent	--	--	--	--	--	--	--	--
CBA Tail Gas Incinerator	6,084	--	86,207	--	--	3,342	--	--
Steam Boilers	10.2	--	67,605	--	82.4	0.4	9.0	1.8
Emergency Plant Flare[1]	--	--	--	--	--	126.8	--	--
Dehydration Unit Regeneration Heaters	0.24	--	1,713	--	3.48	0.01	0.2	0.04
Plantwide Fugitive Hydrocarbons	--	--	--	--	--	--	--	8.8
Emergency Power Generator	1.1	--	--	--	5.0	0.3	0.4	0.5
Misc. Plant Heaters	--	--	--	--	1.6	--	--	--
Methanol Storage	--	--	--	--	--	--	--	0.1
Well Field Sites (Emission rates represent those occurring at each well site.)								
Diesel-Fired Drilling	49.7	--	--	--	229.9	15.3	15.3	21.9
Diesel Fuel Storage	--	--	--	--	--	--	--	0.04
Wellhead Flare (Well Testing)	--	--	--	--	--	23.7	--	--
Wellhead Heaters	0.09	--	--	--	0.56	0.004	0.07	0.04
Wellhead Flare (Dehydration Units)	--	--	--	--	--	9.1	--	--

TABLE 3-5

RILEY RIDGE PROJECT EMISSIONS INVENTORY

AMERICAN QUASAR

	Emission Rate (g/s)								Emission Frequency		Stack Parameters			
Source Description	CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC	Hrs/Day	Days/Yr	Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temp (°K)
Gas Treatment Plant (Emission rates represent one plant at 1.2 billion scfd.)														
Selexol CO_2 Vent	--	17.5	420,525	3.35	--	--	--	--	24	365	30.5	1.52	19.81	288.7
N_2 Vent	--	--	15,070	1.54	--	--	--	--	24	365	30.5	0.61	28.96	288.7
SCOT Tail Gas Incinerator	--	--	70,370	--	--	165.3	--	--	24	365	61.0	1.52	25.91	505.4
Steam Boilers	0.25	--	2,235	--	1.97	0.01	0.22	--	24	14	29.9	0.76	19.81	477.6
Emergency Plant Flare[1]	--	--	646,214	--	--	40,836	--	--	1	1	61.0	1.68	41.15	977.6
Dehydration Heater	0.03	--	186.0	--	0.19	0.0008	0.02	--	12	365	5.3	0.13	22.86	672.0
Initial Module Start-up and Emergency Flaring Operations	--	--	107,702	--	--	6,806	--	--	4	7.5	61.0	1.68	41.15	977.6
Diesel Fuel Storage	--	--	--	--	--	--	--	0.02	24	365		Not Applicable		
Well Field Sites (Emission rates represent those occurring at each well site.)														
Diesel Fired Drilling	3.44	--	--	--	15.96	1.05	1.18	1.47	24	230	9.1	0.15	45.72	810.9
Diesel Fuel Storage	--	--	--	--	--	--	--	0.0004	24	365		Not Applicable		
Wellhead Flare (Well Testing)	--	--	--	--	--	33.14	--	--	24	1	31.2	0.10	121.9	977.6
Gas Heaters (Well Start-up)	0.03	--	--	--	0.16	0.0006	0.02	0.01	8	18	15.2	0.38	30.48	810.9

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[1] Emissions represent flaring for the entire plant.

TABLE 3-6

RILEY RIDGE PROJECT ANNUAL EMISSIONS (TONS/YEAR)

AMERICAN QUASAR

Source Description	CO	COS	CO_2	H_2S	NO_x	SO_2	TSP	VOC
Gas Treatment Plant (Emission rates represent one plant at 1.2 billion scfd.)								
Selexol CO_2 Vent	--	607	14.62×10^6	116.4	--	--	--	--
N_2 Vent	--	--	523,900	53.6	--	--	--	--
SCOT Tail Gas Incinerator	--	--	2.45×10^6	--	--	4,250	--	--
Steam Boilers	0.33	--	2,980	--	2.6	0.01	0.3	--
Emergency Plant Flare[1]	--	--	2,564	--	--	162	--	--
Dehydration Heater	0.5	--	3,232	--	3.3	0.01	0.4	--
Initial Module Start-up and Emergency Flaring Operations	--	--	12,822	--	--	810	--	--
Diesel Fuel Storage	--	--	--	--	--	--	--	0.6
Well Field Sites (Emission rates represent those occurring at each well site.)								
Diesel-Fired Drilling	75.4	--	--	--	349.6	23.0	25.8	32.2
Diesel Fuel Storage	--	--	--	--	--	--	--	0.01
Wellhead Flare (Well Testing)	--	--	--	--	--	3.2	--	--
Gas Heaters (Well Start-up)	0.02	--	--	--	0.1	0.0004	0.01	0.01

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[1] Emissions represent flaring for the entire plant.

Exxon Facilities

Two identical 600-million SCFD gas treatment plants at Big Mesa and West Dry Basin would produce pipeline quality gas originating from Exxon's sour gas well fields. Each plant would consist of three 200-million SCFD modules. As alternatives, one facility at Shute Creek would process the entire 1.2 billion SCFD from the sour gas well fields, or the two 600-million SCFD plants would be built at East Dry Basin and West Dry Basin.

Following dehydration in the well field, sour feed gas from the gathering system would enter each plant. A gas sweetening unit would remove the acid gas components (H_2S and CO_2) from the sweet gas (CH_4 and N_2), and also split the acid gas into a CO_2-rich stream for atmospheric venting (CO_2 would be compressed and transported when a market develops) and an H_2S-rich gas suitable for feed to a sulfur recovery unit. The Selexol process is currently planned for acid gas removal. The treated gas stream would then be dried in molecular sieve final dehydrators, fractionated in a cryogenic nitrogen rejection unit (yielding a nitrogen-rich gas containing helium which is vented to the atmosphere), and compressed to obtain pipeline-quality natural gas. Helium recovery is also being considered with production of a 50 percent stream to be transported to a processing unit. The sulfur recovery unit would convert the H_2S to elemental sulfur for sale. The combined desulfurization systems would be designed to recover about 99.8 percent of the plant feed stream sulfur.

The Selexol process removes H_2S and CO_2 from the plant feed gas by selective absorption. Regeneration of the Selexol solvent yields an H_2S-rich stream that proceeds to a conventional Claus plant for sulfur recovery, and a low temperature CO_2-rich stream that is vented directly to the atmosphere. The CO_2 vent gas is composed almost entirely of CO_2 (99+ percent), but also includes residual H_2S ($\leq$5.0 parts/ million by volume) and carbonyl sulfide (COS).

The proposed sulfur recovery system consists of a Claus plant and Shell Claus Off-Gas Treating (SCOT) tail gas clean up system. The Claus plant is fed by a concentrated H_2S-rich gas stream from the Selexol process. Ambient air is also introduced into the first stage of the Claus process, which oxidizes a portion of the H_2S feed into SO_2, thus forming the necessary reactants for the Claus reaction ($2\ H_2S + SO_2 \rightleftarrows 2\ H_2O + 3\ S$) to produce elemental sulfur in subsequent reactor stages. The Claus plant tail gas, which contains some unreacted H_2S, is sent to the SCOT unit for additional sulfur conversion and recovery. The tail gas from the SCOT unit is then sent to an incinerator, where all residual sulfur compounds are combusted to form SO_2 prior to discharge to the atmosphere.

Other than the SCOT tail gas incinerator, the only other continuous fuel burning sources in the treatment plant are three 2-million Btu/hour regeneration gas heaters. These natural gas-fired heaters are part of the final dehydration system, located upstream of the nitrogen rejection unit.

At each treatment plant, two start-up/auxilliary boilers would serve all three modules by generating steam for a two- to three-day period when one of the modules is being put on stream. Once each plant is running, the boilers can be shut down because the plants would become steam self-sufficient by utilizing steam generated in the Claus sulfur recovery and the SCOT tail gas units. (However, in the winter the boilers would still be required.) In total, these start-up/auxilliary boilers would operate about 110 days per year.

Exxon plans to purchase electrical power from Utah Power and Light Company. In the event of a power outage, diesel-driven emergency generators would provide electricity. Other support facilities for each treatment plant and the sulfur loadout facilities would consist of a flare to accommodate plant start-ups and emergency upset conditions, diesel fuel and organic solvent storage facilities, molten sulfur storage facilities, emergency sulfur block storage, and a small steam boiler (1-million Btu/hour).

Northwest Facilities

Northwest proposes to construct one gas treatment plant at Craven Creek to process 400 million SCFD of sour gas produced from Mobil's well field facilities. As an alternative the facility would be constructed at East Dry Basin. As discussed earlier, primary dehydration would be performed in the well field. At the plant, a Selexol acid gas removal system would remove H_2S, COS, other sulfur compounds (if any) and carbon dioxide from the sour feed gas. This produces a sweetened methane stream and carbon dioxide stream, as well as an H_2S-rich stream to feed the Claus sulfur recovery unit. Following acid gas removal, the sweetened gas would then be fed to a catalytic hydrolysis reactor where residual COS would be converted to H_2S which is then removed in a trim H_2S contactor using lean selexol solvent. The sweetened gas stream would subsequently undergo final dehydration prior to nitrogen rejection and crude helium recovery. The nitrogen rejection system is a cryogenic operation which produces a nitrogen-rich vent gas containing helium. However, the helium could be separated and may be considered for upgrading to a saleable by-product. The final dehydration system would utilize a 3-million Btu/hour regeneration gas heater which would be fired by clean natural gas.

Elemental sulfur would be recovered using modified Claus technology followed by a tail gas cleanup process. In the Claus unit, a proprietary catalyst would hydrolyze COS and CS_2 and because of the operating conditions, the potential for net generation of COS and CS_2 would be minimized. The Amoco Cold Bed Adsorption (CBA) process has been selected by Northwest for Claus tail gas cleanup. The CBA reactor system, coupled with the Claus process, increases the overall plant sulfur recovery to approximately 99.4 percent. The SO_2, H_2S, and COS emissions in Tables 3-3 and 3-4 reflect this sulfur control. The CBA tail gas is then incinerated to combust all residual sulfur compounds to SO_2 prior to discharge to the atmosphere. Produced sulfur would be kept in a molten state, stored in an adjacent underground storage pit, and pumped from the pit directly to heated rail cars. Sulfur would be diverted to solidified block storage only when necessary. In the event of mechanical problems, or should the sulfur sales market deteriorate, a large area would be needed for block sulfur storage.

Three gas-fired steam boilers, each rated at about 40,000 pounds/hour, would be utilized to meet plant turndown and peak winter and/or start-up steam requirements. Normal summer steam production in the boilers is the minimum required to keep them in readiness to service plant upsets.

Electric power would be obtained from Utah Power and Light Company's Naughton Power Plant south of Kemmerer. To meet minimum electric power requirements during a power supply outage, an emergency diesel generator would serve the critical plant loads. Other support facilities include a plant flare system to combust process gas during plant start-ups and upset conditions, hydrocarbon storage tanks, and miscellaneous heaters for storage tanks. Fugitive VOC from plant refrigeration systems would be a minor hydrocarbon source.

American Quasar Facilities

The proposed 1.2-billion SCFD plant site at East Dry Basin by American Quasar would include up to six modules, each capable of processing 200 million SCFD of sour gas from American Quasar's and Williams well fields. As an alternative, American Quasar proposes to construct the plant at the Buckhorn site. Each module's facilities would be very similar to those described for Exxon's treatment plant and would consist of a gas receiving area; a selective Selexol treatment system; a combined Claus and SCOT sulfur recovery unit followed by a tail gas incinerator; a nitrogen rejection unit; and a regeneration gas heater for the final dehydration system. Associated facilities would include a steam boiler system, a plant flare, and diesel fuel storage tanks.

The treatment plant requires about 175 megawatts of electric power to operate. This power would be supplied by a transmission line from the Naughton Power Plant. American Quasar would participate jointly with Exxon on the molten sulfur pipeline, described previously.

Gas Treatment Plant and Ancillary Facilities Emissions

The gas treatment plant and ancillary facilities operations would result in significant quantities of air emissions. Tables 3-1 through 3-6 list these emissions for Exxon, Northwest Pipeline, and American Quasar, respectively. As described previously, two tables are provided for each company, one containing short-term emission rates and the other annual average emissions rates. On an annual basis, the largest sources of SO_2 are the SCOT and CBA tail gas incinerators, followed by the dehydration upset and emergency plant flares. The largest sources of NO_x are the steam boilers at the Northwest plant, followed by emergency generators at Exxon's plants and at the sulfur loadout. Particulate emissions, relatively small in comparison to SO_2 and NO_x emissions, occur primarily from emergency generators and auxiliary steam boilers. There are also some sulfur particulate emissions associated with the Exxon/American Quasar sulfur terminal. The largest sources of CO_2, H_2S, and COS are the CO_2 vents at the various plants. Nitrogen vents are secondary sources of H_2S and CO_2. CO emissions result primarily from the CBA tail gas incinerator and secondarily from emergency generators. Although not listed in the tables, helium would also be emitted from the nitrogen vents.

The gas treatment plant emissions in Tables 3-1 through 3-6 are based on preliminary engineering studies performed by the applicants and verified by ERT. These studies include the conceptual design and integration of required unit operations, based on known or vendor-guaranteed design and performance characteristics of the equipment, as well as on pollutant material balances for each applicable piece of equipment and for the plant as a whole. In certain cases, ERT independently developed approximate estimates of missing critical emissions in order to complete the air emissions inventory. Also, where appropriate for similar sources of emissions within the proposed facilities, the individual data bases provided by some applicants were employed to supplement missing information for other applicants.

CONSTRUCTION OF WELL FIELDS, PLANTS, AND PIPELINES

Construction activities can generate significant quantities of fugitive dust, particularly in wind-blown, semi-arid regions such as the Riley Ridge area where scant vegetation, little precipitation, and strong winds allow relatively dry topsoil and subsoil to be entrained into the air. Fugitive dust of this type generally contains a high fraction of large particulates that tend to settle out quickly. However, some of the dust can be relatively fine and thus transported much further downwind (like gaseous emissions).

The following subsections describe the construction-related activities for the applicants based on information provided in their Right-of-Way Applications (Exxon 1982; American Quasar 1982; Northwest 1982). These activities are divided by well pad and access road construction, sour gas pipeline and trunk line construction, gas treatment plant construction, and sales pipeline and ancillary facilities construction. The last subsection summarizes the methods used to calculate the fugitive dust emissions as well as the resultant inventories. Appendix 1 contains the detailed fugitive dust emissions calculations.

Well Pad and Access Road Construction

The numbers indicated in this section were used in the air quality analysis and may differ from final mileages and acreages shown in the EIS.

Exxon Facilities

A total of 75 wells are currently planned by Exxon to be spaced initially at one well per 640 acres. Each site would be cleared, leveled, compacted, and graveled as necessary to support the facilities. The foundations would require excavation, formwork, concrete placing and curing, formwork removal, and backfilling and compaction operations. Construction procedures would include implementation of erosion control and revegetation measures to assure that lands disturbed by construction activities would be restored as soon as practicable to a stable, productive, and aesthetically acceptable condition. Fugitive dust would be controlled by wetting down areas as necessary.

Approximately 140 miles of access roads to the well sites are currently planned. Of this, 68 miles would be existing light-duty roads requiring only maintenance; 46 miles would be existing unimproved roads requiring upgrading and maintenance; and 27 miles would be new roads. Existing roads would be used wherever practicable. A construction right-of-way width of 50 feet would be required to construct new roads and to upgrade existing unimproved roads. The major activities for road construction would be clearing, topsoil stripping, excavation, construction of drainage ditches and drainage structures, surfacing, cleanup, and restoration of cut and fill slopes.

Mobil Facilities

Construction techniques and procedures for the components of the Mobil well field would be standard, state-of-the-art techniques, common to the area. The well pad area is usually about 400 feet square. Preparation would involve the following earthwork: the land would be leveled, dirt pits would be excavated for the sump pits, and an access road would be constructed so that equipment could be brought to the site. Fugitive dust would be controlled by wetting down areas as necessary. Erosion control and associated revegetation measures would be incorporated to further minimize wind blown dust from exposed subsoil.

For the most part, the wells to be drilled are adjacent to existing roads and wells. This greatly reduces the amount of new access road construction in the well field. It is estimated that there would be 8 to 10 miles of new access roads built for the 67 wells. These roads would be extensions of existing dirt roads and would be sized and constructed in the same manner.

After a well is placed in operation, approximately one acre of space would be needed for wellhead facilities. The remaining acreage would be reclaimed and restored. A total of 67 wells would eventually be drilled and would disturb approximately 248 acres, with 67 acres occupied during production.

American Quasar and Williams Facilities

The American Quasar gas field (Riley Ridge and proposed North Riley Ridge and Darby Mountain Units) would be composed of 72 wells to be developed by 1989 (one developed jointly with Williams Exploration Company). Williams proposes to develop 24 wells by 1990 at a rate of about 3 wells per year. Existing power lines would be utilized wherever possible, otherwise new lines would be run underground in existing rights-of-way. The total surface acreage disturbance for the gas field access roads and well sites would be approximately 593 acres by American Quasar and 255 acres by Williams. Well pad preparation generally involves the following earthwork: the land is leveled, an unlined reserve mud pit is excavated, and an access road constructed so that equipment can be brought to the site.

Access roads would be constructed to each well site using existing roads wherever possible. New roads would be designed to minimize additional disturbance. Present plans by American Quasar call for an estimated 92.2 miles of access roads (new and improved) requiring a 30-foot right-of-way width. Present plans by Williams call for 27 miles of access roads (new and improved), with a 35-foot right-of-way width. The disturbance area should not exceed 30 to 35 feet for permanent roads.

Sour Gas Pipeline and Trunk Line Construction

Exxon Facilities

When all 75 wells are producing, there would be approximately 108 miles of sour gas gathering pipelines with assumed right-of-way widths of 100 feet. The total disturbance is estimated at 1,300 acres.

Typically, pipelines would be laid in a continuous operation of a "spread", consisting of equipment and crews handling various types of construction activities for a given pipeline segment. The major activities would be: clearing, trenching, stringing, bending, lineup, welding, radiographic examination of the pipes, coating and wrapping of the pipes, lowering in of pipes, backfilling the trench, hydrostatic testing of the pipelines, tie-in of the pipelines, and cleanup and restoration of the sites.

The clearing of pipeline routes located on gentle topography would require the removal and smoothing of the brush and surface irregularities. Most of the underlying vegetation would be left undisturbed. The depth of the trench would vary with the conditions encountered. The cover from the top of the pipe to ground level would generally be a minimum of 5 feet. In areas of loose or unconsolidated rock, the trench line would be mechanically ripped or blasted.

Northwest/Mobil Facilities

Untreated or sour gas would be collected from producing wells by a pipeline gathering system. When all 67 wells are producing, there would be 70 to 75 miles of gathering system pipeline. This would disturb from 425 to 455 acres. The main trunk line from the gathering system to the plant would be approximately 43 miles long and would disturb about 390 acres.

Construction would take place in a planned sequence of operations (common to all pipeline construction), along a zone of continuous activity confined to the right-of-way. Bulldozers would be used to clear the right-of-way of all vegetation except short ground cover; obstacles removed; and abrupt changes in ground contours would then be smoothed. Once the right-of-way has been prepared, a trench would be dug with a rotary-wheeled ditching machine or a backhoe. The trench is usually excavated to a depth which allows a minimum of 5 feet of cover over the pipe. In areas where rock is encountered, a tractor-drawn ripper would break and loosen the section, and a backhoe then opens the trench. If the material cannot be ripped, it would be blasted and removed with a backhoe. The pipe would then be lowered directly into the trench and backfilled with the excavated material. Pipeline construction in this area is limited by weather, to the time of year between April and October. Construction is anticipated to take place in one construction season.

American Quasar Facilities

The rights-of-way for the sour gas gathering system (which would end at the trunk line), would be approximately 72 miles long, including rights-of-way for proposed and future well sites. Construction of the gathering system to the trunk line would disturb approximately 436 acres of land.

The proposed right-of-way grant would be for a 50-foot wide corridor. Construction activities would be confined to this right-of-way along most of the length of the proposed gathering line, trunk line, and sales line. Routes located on gentle topography would require only the removal of brush and surface irregularities.

Once the right-of-way is prepared, stringing, welding, and ditching operations would begin. A ditch, 20 to 40 inches wide and 42 to 64 inches deep, would be centered on a line about 15 feet away from one edge of the right-of-way. The ditch would be excavated mechanically with ditching equipment. The ditch would be open no more than 7 miles and for no longer than 14 days at a time during each construction spread. In areas where loose or unconsolidated rock is encountered, the ditch would be excavated with backhoes and clamshell buckets.

If the encountered material cannot be ripped, it would be blasted. In preparation for blasting, unconsolidated material would be removed from the ditch line, and a series of holes would be drilled. Excavation and cut slope material would be stockpiled for later use in rehabilitation operations. These stockpiles would be stabilized and kept separate from topsoil stockpiles. Backfilling over the pipe would be done with auger units mounted on a bulldozer which would compact the fill, thus reducing settling. Materials that cannot be placed in the ditch would be crowned on top of the ditch to compensate for future settling.

Gas Treatment Plant Construction

Exxon Plants

The construction and permanent operation right-of-way for the two gas treatment plants is 640 acres each, or a total of about 1,280 acres. Each plant site would be cleared and graded prior to construction. Approximately 90,000 cubic yards of gravel would be needed for surfacing material at each site. The topsoil would be stripped and stockpiled. The stockpile would be dressed and the slopes stabilized to prevent loss from wind and run-off. After the plant is constructed, all areas not required for operation would be rehabilitated. Each completed plant would occupy about 160 acres. The prime plant sites are Big Mesa and West Dry Basin. At the Shute Creek alternative 1.2 billion SCFD capacity plant would be built. A second alternative would consist of two plants, one at West Dry Basin and one at East Dry Basin.

Northwest Plant

The prime site for the treatment plant is Craven Creek, located approximately 40 miles south of the well field. An alternative site is East Dry Basin. The amount of land to be leased for the plant site is 640 acres. Construction space would require about 255 acres. This includes, in addition to facilities being constructed, equipment storage space, material laydown space, and all temporary construction buildings. The finished plant site would occupy about 55 acres.

Site grading would be accomplished with conventional earthmoving methods, although some of the shale and sandstone formations would require ripping. Some of this material may be usable for road base or structural fill. Site grading would be required for approximately 160 acres. Principal operating units would be located in areas requiring the removal of up to 10 feet of natural terrain depth.

American Quasar Plant

The treatment plant would consist of six 200-million SCFD modules, each about 1,230 feet square. The entire plant site would require about 640 acres, including a 40-acre sulfur storage area. The components, which would be constructed for the treatment plant, include an improved access road, a sulfur storage area, foundations for associated buildings, and the modules for processing the gas. The prime site is East Dry Basin. The Buckhorn site is an alternative.

Sales Gas Pipelines and Ancillary Facilities Construction

Exxon Facilities

The planned product sales pipelines would consist of approximately 93 miles of pipeline each for CO_2 and sales gas. The construction and permanent operation right-of-way width would be 100 feet. The acreage disturbed would be reclaimed.

The molten sulfur pipeline would be jointly owned by Exxon and American Quasar and would be approximately 55 miles in length. The pipeline would originate from the Exxon plants and run to its terminus east of Opal, Wyoming. The pipeline construction and permanent operation right-of-way width would be 75 feet and 60 feet, respectively. The pipeline would be constructed above ground on 8-inch diameter pipe piles.

Construction of the sulfur loadout facilities would utilize standard industrial-scale construction techniques. The site would be graded with heavy earthmoving equipment to accommodate the necessary rail trackage and the storage, loadout, and associated structures. The auxiliary facilities would require a construction and permanent right-of-way of 240 acres.

The electrical transmission line would be approximately 87 miles in length. The area disturbed during construction would be reclaimed. The required right-of-way width would be 50 feet.

Northwest/Mobil Facilities

The sales gas pipeline would be constructed in much the same manner as the sour gas pipelines. The sales gas pipeline would be about 3 miles long and would disturb about 18 acres.

A railroad spur constructed to the Craven Creek site would be approximately 7.6 miles long with a right-of-way width of up to 100 feet; however, actual construction would utilize a 42-foot width. Earthwork would include grading, cutting and filling bridges and culverts, construction of the road bed, followed by placement of the actual rails, cross ties, and ballast. Earthwork for the road bed can be done in about 90 days using standard earthmoving equipment.

Electrical power would be obtained from the Utah Power and Light system at the Naughton Power Plant. The transmission line from the plant would cover a distance of approximately 25 miles with a right-of-way width of 150 feet. Construction would take place within the permanent right-of-way. At the structure sites, enough brush would be cleared to provide a clean tower assembly and erection area. Footings for the structures require the excavation of 10-foot deep holes at the location of each structure leg. If the local substrate is rock, drilling and blasting may be required. Spoil dirt is piled nearby for backfilling. Erection of tall structures requires that excavating equipment, concrete trucks, supply trucks, and a crane, be able to reach each structure site. Thus, in rough terrain it may be necessary to construct some spurs from existing roads to the structure sites.

In Mobil's well field there is an extensive woodpole-mounted power line system in the two units. This system would be expanded to include the sour gas wells as they are drilled. The proposed wells would expand the existing power system by 25 to 30 miles.

American Quasar Facilities

Two sales gas pipelines, transporting CO_2 and methane in the same right-of-way would extend from the plant site to a terminus near the proposed Trailblazer Pipeline System. The surface disturbance of the sales gas pipeline, with a 50-foot right-of-way width, would be approximately 518 acres from the East Dry Basin site.

As discussed previously, a molten sulfur pipeline would run from the selected plant site to its terminus east of Opal, Wyoming. The sulfur by-product pipeline system would be jointly owned by Exxon and American Quasar. For the proposed East Dry Basin site, pipeline length would be about 54 miles and surface disturbance about 393 acres. Construction procedures for the molten sulfur pipeline would be similar to those for the gathering, trunk line, and sales gas pipelines, with the major exception that no ditching would be required because the pipeline would be above ground. Loadout facilities would be constructed at a site near Opal, Wyoming. The loadout facilities would include railcar loading facilities, sulfur storage and handling facilities, and water treatment facilities. The plant would require a power line from the Naughton Power Plant.

Construction-Related Emissions

The fugitive dust emissions from the construction activities described in previous sections were calculated by ERT from emissions factors generally used by the WDEQ (undated) and by EPA Region VIII (1979). Note that for several of these activities the emissions factors were originally measured for similar activities at surface coal mines. Because the earth-moving activities at surface coal mines are likely more intensive than similar activities associated with the construction of the Riley Ridge Project, the Riley Ridge construction emissions inventory is considered an upper estimate of the range of expected emissions, i.e., conservatively high.

Table 3-7 summarizes the fugitive dust emissions from the various construction activities planned by each applicant. Emissions associated with construction of the joint Exxon/Quasar molten sulfur pipeline are split equally between the two applicants.

As shown in Table 3-7, the fugitive dust emissions resulting from Exxon's planned development occur primarily from construction of the sales gas pipeline and sour gas pipelines, as well as from associated vehicular traffic on unpaved roads in the early years of construction. Based on the year-by-year Exxon totals, 1985 is estimated to be the year of highest fugitive dust emissions.

The fugitive emissions for the Northwest/Mobil construction activities result primarily from similar activities, but are smaller due primarily to the smaller size of the Northwest facilities. The highest emission rate of 817 tons/year is expected in 1984.

TABLE 3-7

CONSTRUCTION-RELATED FUGITIVE DUST EMISSIONS ESTIMATES
(TONS/YEAR)

Operation	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994 - 1999	2000 - 2009
Exxon														
Gas Plant			325	46	0	46	325	46	0	46				
Access Roads			3	3	3	3	3	3	3	3	3	3		
Gas Gathering			130	130	130	130	130	130	130	130	130	130		
Well Drilling			51	51	51	51	51	51	51	51	51	51		
Sales Pipe			372	372	372									
Sulfur Pipeline and Loadout			140	140	140									
Traffic			55	416	325	93	97	746	514	540	305	232		
Total Exxon			1,076	1,158	1,021	323	606	976	698	770	489	416		
Northwest & Mobil														
Gas Plant			557											
Access Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Gathering			213	213	213	213								
Well Drilling	8	8	8	8	8	8	8	8	8	8	8	12	12	8
Rail Spur				25										
Trans. Line				0										
Traffic			39	39	103	40								
Total NW & Mobil	8	8	817	285	324	261	8	8	8	8	8	12	12	8

TABLE 3-7 (CONTINUED)

Operation	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994 - 1999	2000 - 2009
American Quasar														
Gas Plant				129	65	129	65							
Access Roads	0	0	0	0	0	0	0	0						
Gas Gathering			83	83	83	83	83	83						
Well Drilling	34	34	34	34	34	34	34	34						
Sales Pipe			167	167	167									
Sulfur Pipeline			63	63	63									
Traffic			63	150	164	165	165	165						
Total Am. Quas	34	34	410	626	576	411	347	282						
Williams Exploration														
Access Roads			0	0	0	0	0	0	0					
Gas Gathering			0	0	50	50	50	50	50					
Well Drilling			14	14	14	14	14	14	14					
Traffic			35	36	36	37	37	37	37					
Total Williams Expl.			49	50	100	101	101	101	101					
GRAND TOTAL All Projects	34	34	2,352	2,059	2,021	1,096	1,062	1,367	807	778	497	428	12	8

Quasar's total emissions are larger than Northwest's but smaller than Exxon's. However, since their construction activities are spread over a longer time frame than Northwest's, their maximum annual emission rate of 626 tons/year is lower than Northwest's maximum.

The fugitive dust emissions for Williams Exploration are very small in comparison to the other companies. Williams maximum annual emissions are 101 tons/year.

SECONDARY GROWTH AND RELATED EMISSIONS

The population increases which would be expected in southwestern Wyoming due to the Riley Ridge Project are summarized in Table 3-8. (The numbers may differ from the final numbers appearing in the EIS.) The largest local population increases for the Proposed Action, Buckhorn Alternative, and Shute Creek Alternative would occur in the Kemmerer-Diamondville area in 1986. For either the Proposed Action or the Buckhorn Alternative, these two communities would experience a projected population increase of about 3,495 people. If the Shute Creek Alternative is selected, the population increase would be about 4,357 people. For the Northern Alternative, the largest increases would occur in the Big Piney/Marbleton area during 1986. This population increase is projected to be about 2,186 people.

The air pollutant emissions of such population increases would occur primarily from residential space heating, open refuse burning, and vehicular exhaust. Based upon surveys of Fremont and Teton County residents in 1979 performed by the Wyoming Energy Conservation Office (1982), space heating requirements are met primarily by using natural gas, electricity, and wood (in decreasing order of preference). Negligible quantities of coal were used for this purpose. Consequently, in this analysis, it was assumed that air emissions due to residential space heating would be due to natural gas and wood combustion. Data published in the Statistical Abstract of the United States by the Department of Commerce (1978) were used to estimate the number of persons per household, natural gas sales in Wyoming, and residential natural gas customers in Wyoming. Domestic space heating emission factors were taken from the EPA publication, Compilation of Air Pollutant Emissions Factors (1981). Survey results indicated that annual wood consumption averages 2.68 cords per household (2.96 and 2.4 in Fremont and Teton County, respectively). Additional information required for calculating secondary growth emissions due to space heating via natural gas and wood is specified in Table 3-9.

Air emissions due to refuse burning in "backyard barrels" and open pits, were assessed using data in EPA's Compilation of Air Pollutant Emission Factors. This information is also provided in Table 3-9. To conservatively assess these emissions, it was assumed that all refuse would be combusted using these open burning techniques.

Regarding vehicular emissions, estimates of the number of vehicles per household, and miles driven per vehicle were extracted from the Statistical Abstract of the United States. Emission factors for these calculations were taken from the EPA's Mobile Source Emission Factors (1979) and Compilation of Air Pollutant Emission Factors.

Based on the emissions factors and other data in Tables 3-8 and 3-9, emissions inventories were developed for the criteria pollutant species SO_2,

TABLE 3-8

MAXIMUM ESTIMATED POPULATION INCREASES FROM RILEY RIDGE PROJECT

County	Community	Proposed Action, or Buckhorn Alternative		Shute Creek Alternative		Northern Alternative	
		Population Increase[1]	Year	Population Increase[1]	Year	Population Increase[1]	Year
Lincoln	Afton	20	1986	22	1986	19	1986
	Cokeville	62	1986	68	1986	55	1986
	Diamondville	1,267	1986	1,593	1986	643	1985
	Kemmerer	2,228	1986	2,764	1986	1,220	1985
	LaBarge	1,206	1985	928	1985	1,670	1986
	Thayne	6	1985	6	1985	7	1985
Sublette	Big Piney	836	1985	609	1985	1,138	1986
	Marbleton	771	1985	564	1985	1,048	1986
	Pinedale	160	1985	124	1985	209	1986
Sweetwater	Granger	118	1986	145	1986	73	1985
	Green River	555	1986	632	1986	416	1985
	Rock Springs	454	1986	505	1986	368	1985
	South Superior	33	1986	35	1985	28	1985
	Wamsutter	15	1985	15	1985	14	1985

Source: Western Research Corporation; Laramie, Wyoming (1982)

[1] Based on County Level Economic Analysis

TABLE 3-9

ASSUMPTIONS MADE IN CALCULATING SECONDARY GROWTH AIR EMISSION RATES

Data		Data Source
Vehicle Emission Factors for 1986		
Hydrocarbons	3.9 g/mile	EPA 1979
Carbon Monoxide	40.7 g/mile	EPA 1979
Nitrogen Oxide	2.5 g/mile	EPA 1979
Sulfur Dioxide	.19 g/mile	EPA 1981
Particulates	.41 g/mile	EPA 1981
Miles Driven/Vehicle	11,600/Year	DOC 1978
Vehicles/Household	1.28	DOC 1978
Domestic Space Heating Emission Factors Natural Gas Heating		
Particulates	15 lb/10^6 ft^3	EPA 1981
Sulfur Oxides	0.6 lb/10^6 ft^3	EPA 1981
Carbon Monoxide	20 lb/10^6 ft^3	EPA 1981
Hydrocarbons	8 lb/10^6 ft^3	EPA 1981
Nitrogen Oxides	80 lb/10^6 ft^3	EPA 1981
Gross Heating Value of Natural Gas	1050 Btu/scf	EPA 1981
Population/Household	2.92 People	DOC 1978
Natural Gas Sales in Wyoming (1977)	13 x 10^{12} Btu/Year	DOC 1978
Residential Natural Gas Customers in Wyoming (1977)	96,000	DOC 1978
Wood Stove Heating		
Particulates	30 lb/ton wood	EPA 1981
Carbon Monoxide	260 lb/ton wood	EPA 1981
Tons wood per cord	2.34	USFS 1982
Open Rufuse Burning		
Particulates	16 lb/ton refuse	EPA 1981
Sulfur Oxides	1 lb/ton refuse	EPA 1981
Carbon Monoxide	85 lb/ton refuse	EPA 1981
Hydrocarbons	30 lb/ton refuse	EPA 1981
Nitrogen Oxides	6 lb/ton refuse	EPA 1981
Refuse per capita	5.5 lb/day	EPA 1981

CO, HC, NO_x, and particulates for the area associated with the greatest population growth. These emissions are summarized in Table 3-10.

DISPERSION METEOROLOGY DATA DEVELOPMENT

SEASONAL AND ANNUAL METEOROLOGY

As discussed in Chapter 1, Affected Environment, the most representative set of meteorological data now available for seasonal and annual impact modeling is judged to be the Fort Bridger data. (Even though the data are about 30 years old, they should be representative in a climatic sense because the Fort Bridger wind roses are very similar to wind roses calculated from more recent wind data in the area.) The rationale for the choice of the Fort Bridger data includes:

- The proximity of the Fort Bridger site to the Riley Ridge Project area;
- The site's "favorable" exposure, that is, with terrain to the west; and
- The period of record.

Hourly stability classes in the Fort Bridger data set were previously derived by the National Climatic Center (NCC) from the conventional Turner (1964) scheme, which is based on observed wind speeds, cloud cover, ceiling height, and time of day. The NCC combined the hourly stability classes with the hourly wind data to develop an annual stability wind rose for Fort Bridger. Seasonal average morning and afternoon mixing heights were taken from Holzworth's (1972) data for Lander, Wyoming. To estimate the variation of mixing height with atmospheric stability, the method used in the WDEQ version (1980) of the EPA CDM model was adopted.

A stability wind rose was also required for the acid deposition modeling assessment. The period of interest in the acid deposition assessment is October through March, which is the period associated with snowfall in the Bridger Wilderness. This six-month "wintertime" period is not explicitly covered by the existing Fort Bridger seasonal stability wind roses. Therefore, this stability wind rose was constructed by taking a weighted average of the available Fort Bridger wind roses. The available stability wind roses were weighted as follows:

- Fall (September - November): 2/6;
- Winter (December - February): 3/6; and
- Spring (March - May): 1/6.

SHORT-TERM METEOROLOGY

Ideally, for modeling maximum short-term impacts of the Riley Ridge Project a one-year set of representative, sequential hourly meteorological data collected on-site would be preferable. Yet, as discussed in Chapter 1, no such data set is now available in the project area. Accordingly, in order to perform "worst-case" screening model calculations of maximum short-term average impacts, it was necessary to construct an artificial data set.

TABLE 3-10

AIR EMISSIONS FROM SECONDARY GROWTH

(TONS/YEAR)

	Emission Rates				
	Space Heating Via				
Pollutant	Natural Gas	Wood	Refuse Burning	Vehicular	Total
Proposed Action, Buckhorn Alternative[1]					
Particulates	1.2	112.4	28.1	7.9	149.6
SO_2	0.1	--	1.6	3.7	5.4
CO	1.6	973.8	148.7	782.0	1,906.1
HC	0.6	--	52.7	75.0	128.3
NO_x	6.2	--	10.6	48.2	65.0
Shute Creek Alternative[1]					
Particulates	1.5	140.3	34.9	9.8	186.5
SO_2	0.1	--	2.2	4.6	6.9
CO	1.9	1,215.8	185.1	974.6	2,377.4
HC	0.8	--	65.4	93.3	159.5
NO_x	7.8	--	13.0	60.0	80.8
Northern Alternative[2]					
Particulates	0.7	70.3	17.6	4.9	93.5
SO_2	0.1	--	1.0	2.3	3.4
CO	1.0	609.1	85.5	489.1	1,184.7
HC	0.4	--	32.9	46.9	80.2
NO_x	3.9	--	6.6	30.1	40.6

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[1] At Kemmerer/Diamondville.

[2] At Big Piney/Marbleton.

Table 3-11 shows the range of "worst-case" meteorological scenarios chosen to calculate short-term impacts, both in the immediate source vicinity as well as more distant existing and proposed Class I areas. These scenarios cover all potential combinations of wind speed and stability class represented in the standard STAR data set, except very low wind speed stable conditions. The models used in this study are felt to give conservatively high concentration estimates for these conditions because wind direction variability under stable light wind speeds is often much higher than assumed in the model calculations. Since each of these stability wind speed combinations is assumed to occur in all (16) wind directions, over 570 total "worst case" scenarios were evaluated.

However, while arbitrarily defined worst-case meteorology can be useful for screening calculations, it cannot reliably describe the persistence of local wind conditions, nor their hour-to-hour variability. To partially overcome this problem, ERT elected to use the Kemmerer Coal data set, the only long-term sequential, hourly data set now available in the general vicinity of the Riley Ridge Project (see Chapter 1). For sequential modeling, use of this basic data set was augmented in two ways:

- Hourly stability classes were assigned based on wind direction fluctuations, following Slade (1968);

- Hourly wind directions, which are described in the Kemmerer data set only within 10-degree intervals, were redistributed uniformly within 1-degree intervals in the EPA's conventional manner, using the EPA (1977) CRSTER model random number sequence.

It was assumed that this augmented data set does describe, to some useful extent, the general persistence and hour-to-hour variability of winds in the Riley Ridge area. Although it is not ideal, this data set is probably the most realistic set presently available for sequential short-term average modeling calculations in the study area.

MODELING OF OPERATIONS-RELATED PRIMARY POLLUTANTS

SELECTION AND USE OF COMPLEX I

Because elevated terrain is present both in the near vicinity of the Riley Ridge Project and in the distant Class I areas, the modeling method must explicitly treat high terrain receptors. For this reason, ERT selected the EPA COMPLEX I dispersion model as the basic assessment model for point sources. COMPLEX I, a sequential, hourly, multiple point source Gaussion plume model, permits assignment of receptors at their actual elevations and computes plume impacts on low or high terrain.

Because COMPLEX I can precisely reproduce the results of the EPA's VALLEY screening model, (i.e., the EPA VALLEY model direct impingement assumption can be used as one option in COMPLEX I) there is no need to use VALLEY as well. In addition, COMPLEX I allows the user more flexibility to choose receptors (rather than spread uniformly along one or another of the 16 cardinal wind directions.) Therefore, COMPLEX I allows choice of receptor densities that will: A) capture the maximum ground level concentrations in the near vicinity of a major source; and B) capture the maximum concentrations from the combined impacts of several sources, at

TABLE 3-11

TABULATION OF WORST-CASE METEOROLOGICAL CONDITIONS[1]

Wind Speed (m/sec)	Stability Class A	B	C	D	E	F
1.0	X	X	X	X		
2.5	X	X	X	X	X	X
4.4	X	X	X	X	X	X
7.0	X	X	X	X	X	X
9.8	X	X	X	X	X	X
12.4	X	X	X	X	X	X
Persistance Factor[2]	6	6	6	24	12	6

[1] "X" denotes this stability/wind speed combination was modeled.

[2] This represents the number of hours in a 24-hour period the "worst-case" conditions were assumed to exist.

longer distances e.g., at the existing and proposed Class I areas. The receptor mesh can easily be refined if a suspected "hot spot" has not been adequately resolved in a previous run.

Normally, COMPLEX I is run with a set of sequential hourly meteorological data (ideally, a full year) assumed to be representative of dispersion conditions at the site. However, as discussed previously, the currently available meteorological data sets are not truly representative of on-site conditions. Accordingly, sets of hypothetical "worst-case" meteorology (that is, hourly sequences of wind speed, direction, and stability class) were constructed to cover the range of adverse dispersion conditions that may be encountered in the Riley Ridge Project area. These sets of "worst-case" meteorological conditions were described previously.

COMPLEX I was also used to obtain annual average point source impacts. For this purpose a post processor was added to the basic model to incorporate the "stability wind rose" method now used in the annual-average version of the VALLEY model. An input meteorological data file of all hourly combinations of wind speed, wind direction, and stability class to be considered was then constructed. The model was run for each of these fictitious "hours", and the hourly results at all receptors were then weighted by the relative annual frequency of occurrence of each combination.

SELECTION OF RECEPTORS

To aid in receptor selection, the EPA model PTPLU was used to determine the elevation range of stable plumes as well as the approximate horizontal extent of maximum low terrain impacts during neutral and unstable conditions.

USGS 7½-minute topographic maps were analyzed to determine the closest terrain with elevation ranges at stable plume centerline for each plant site. "Stable" high-terrain receptors were selected in 30-foot increments throughout the elevation range for each proposed plant site. If, for any given site, this terrain was at a considerable distance, then additional receptors were located at the highest elevations in the intervening terrain. Additional high terrain receptors were also located on the closest terrain for those wind direction sectors in which combined impacts could occur.

In addition to the "stable" high terrain receptors, a rectangular grid of receptors was selected in low and intermediate terrain to determine maximum impacts likely to occur during unstable or neutral conditions. Based upon the PTPLU results, a 1-kilometer grid spacing was used for approximately the first 5 kilometers from each plant boundary; beyond this range, a 2-kilometer grid of receptors was extended to 20 kilometers from each plant site. Since maximum unstable impacts could occur at the plant boundary, the rectangular grids of receptors were also augmented by locating 16 additions on each plant boundary, one in each wind direction sector (22.5°).

Receptors for proposed and mandatory Class I areas (Bridger Wilderness, Scab Creek Wilderness, Teton Wilderness, Teton National Park, and Fossil Buttes National Monument) were selected in the same manner as the "stable" high terrain receptors, except that 100-foot elevation increments were used instead of 30-foot increments. This change was warranted for two reasons: 1) The minimum distances to Class I areas are far enough that the vertical concentration profile should be fairly homogeneous; and 2) Plumes from all proposed combinations of plant sites combine to span a 1,500-foot elevation range (6,900 feet to 8,500 feet). The adequacy of 100-foot elevation increments was confirmed with sensitivity tests of the 1-hour impact using hypothetical worst-case meteorology for the closest plant site/existing or proposed Class I area combination, that is Craven Creek's impact at Fossil Buttes. With receptors located at even 100-foot increments centered on the plume centerline elevation, at most about a 2 percent difference was observed in the concentrations.

In all, more than 1,500 receptors were chosen initially to capture maximum individual and combined impacts from all proposed plant sites. Prior to executing all required model runs, a test run was performed for the two closest sites, West and East Dry Basin (which are closest to each other and to high terrain). This run verified our conjecture that the number of rectangular grid receptors was in fact larger than required. Since no dramatic variations in predicted annual concentrations were detected beyond about 3 kilometers from each plant boundary, the 1-kilometer rectangular grid zone was reduced accordingly. Further analysis of this test run indicated that the fringes of the 2-kilometer grid zone could be reduced considerably, especially in the less frequent wind directions. In this manner, the final receptor package was reduced to a total of 900 (which reduced from 9 to 5 the number of COMPLEX I model runs required for each source) without any consequential degradation in ability to capture maximum annual impacts in the near-field, intermediate, or far-field regions.

Although annual impacts were calculated only at these 900 receptors, no such restriction was imposed for maximum short-term impacts. In fact, the protocol employed was, first, to analyze the maximum 1-hour impacts (see "Selection and Use of COMPLEX I") using the basic 900 receptors; but if a "hot spot" was suspected, then that meteorological condition was rerun with additional receptors to give better definition of "hot spot" impacts. For instance, the maximum 1-hour stable impact from Shute Creek's plume occurred on the Opal Bench to the south, well below plume centerline elevations but considerably closer to the source than terrain at centerline elevation to the west.

MODELING SEQUENCE

Selection of Sources

The impact analyses for the Riley Ridge Project considered all NAAQS and WAAQS pollutants, as well as CO_2, helium, and COS. Temporary sources associated with plant upsets, emergency flaring, and testing were not modeled. All other sources, including the Proposed Action and all other designated alternatives were considered for modeling, but those sources which individually fall below EPA's de minimis emission rates, or which in combination with like source types fall below de minimis emission rates, were excluded from further consideration. Tables 3-1 through 3-6 summarize, by applicant, all sources initially considered as part of the project, and list emission rates by pollutant species, stack parameters, and operating frequency. Note that some of these sources fall below de minimis rates.

Modeling of SO_2 Sources

The principal sources of SO_2 emissions are the tail gas incinerators at the treatment plants and diesel generators at well field sites. All other continuous sources of SO_2 are negligible by comparison.

Tail gas incinerators each exceed the SO_2 de minimis emission criterion. (Of all criterion pollutants emitted by the Riley Ridge Project, the SO_2 emissions from tail gas incinerators are the largest.) These sources are characterized by tall stacks (200 feet for Exxon and American Quasar; 175 feet for Northwest) and buoyant plumes with substantial plume rise. Therefore, they may impact over long ranges. In particular, under stable conditions, the tail gas incinerator plumes may be transported compactly over long distances to high terrain in Class I areas. Additionally, because these elevated sources can impact over large areas, it is necessary to take into account the possible combined impacts of several facilities.

Diesel generator emissions combine to exceed the SO_2 de minimis emission criterion. These sources are characterized by short stacks (e.g., 9.5 feet for Northwest, 10 feet for Exxon, and 30 feet for American Quasar), and modest buoyancy. Therefore, they do not impact over large areas and the impacts are essentially only local (e.g., within 2 kilometers of the well field sites). The receptors of most concern are on locally elevated terrain. For these diesel generator sources, therefore, low-wind, stable-flow conditions are of primary concern for short-term maximum impacts.

The modeling approach for tail gas incinerator SO_2 emissions included in two steps:

- Screening calculations using assumed "worst-case" meteorological conditions
- Sequential hourly modeling with the Kemmerer Coal meteorological data set

The screening calculations were based on sets of hypothetical worst-case meteorological conditions, as described before. For each source and each source combination, two receptor packages were selected: A) "high terrain" receptors, e.g., receptors at stable plume centerline elevations, were selected at the closest elevation terrain with respect to the specific source (or source combination); and B) "low terrain" receptors were chosen in a rectangular grid and on the proposed plant boundary (see previous discussion in Selection of Receptors). For maximum short-term impacts, the combinations of wind speed, wind direction, and stability class listed in Table 3-11 were run for all receptors. At each receptor the highest two 1-hour concentrations were identified. Additionally, the 50 highest 1-hour concentrations (independent of receptor location) were also tabulated. Based upon these results, and the assumed persistence, potential violations were identified in the high-terrain areas (under stable conditions) and at plant boundaries (under unstable conditions).

To refine these "worst-case" screening estimates by taking into account the hour-to-hour variability of meteorological conditions in the area, COMPLEX I sequential modeling with a full year of hourly Kemmerer Coal data was then performed. Additional receptors were located with a 10° resolution in high terrain areas to ensure capturing maximum short-term impacts in the areas of key concern. For individual source impacts the five highest concentrations were obtained at each receptor; for combined impacts, the two highest 3-hour and 24-hour concentrations at each receptor, as well as the highest 50 concentrations independent of receptor, were obtained.

For annual estimates of SO_2 impacts from tail gas incinerators, the screening model results were aggregated by relative frequency of occurrence at Fort Bridger (as previously described--see Selection and Use of COMPLEX I). The annual SO_2 concentration at each receptor was obtained, and the highest of these was identified for compliance with PSD increments, NAAQS, and WAAQS.

The annual average modeling for diesel generator SO_2 emissions followed the "screening" approach described above for tail gas emissions. The year 1985 was selected as the potential worst-case source scenario year because, based on the information available, it is the year in which well field sources would be in closest proximity; combined impacts from multiple generators could be largest. Receptors were located in the prevailing wind direction, at well site boundaries, as well as at nearest terrain points at stable plume centerline elevations. The annual estimates of SO_2 impacts from diesel generators were calculated as described above for tail gas incinerators.

High SO_2 emissions would also occur as a result of plant and well field flaring. Flaring is expected at the Northwest/Mobil well sites for about one-half hour per day every 18 days (about 20 days/year). Flaring at the Exxon dehydration units and all plants would occur on an upset basis only. Annual average SO_2 impacts from flaring were evaluated using the Fort Bridger stability wind rose for the Northwest and Exxon dehydration units and plant facilities at West Dry Basin and East Dry Basin. Other plant sites (Big Mesa, Buckhorn, Craven Creek and Shute Creek) are too far removed or too high in elevation to combine with well field flaring emissions. Short-term flaring impacts were evaluated for Northwest and Exxon using assumed "worst-case" meteorology. Because of the infrequent nature of flaring emissions combined multiple impacts were not specifically modeled. However, based on annual average modeling of one flare, it was determined that annual average emissions from all flares would not significantly increase maximum annual average SO_2 concentrations from plant operations.

The standard plume rise equations in most dispersion models are not appropriate for flares. To compensate for this an alternative procedure was developed. The buoyancy flux term (F) in the plume rise equation was calculated from site-specific data by the equation (Briggs 1969):

$$F = g\ 0.8\ Q_H / \pi\ C_p\ \rho\ T$$

Where g = gravitational acceleration.
Q_H = the heat flux.
C_p = the specific heat of air at constant pressure.
ρ = the density of air.
T = the ambient temperature.
0.8 = a factor which accounts for an assumed 20 percent heat loss from radiational cooling.

The dispersion model inputs (temperature, stack diameter, and exit velocity) were set to yield identical values of F.

Modeling of NO_x Sources

The principal sources of NO_x emissions would be the well field diesel generators and Northwest's steam boiler. All other continuous sources of NO_x are negligible by comparison.

Well field diesel generators each exceed the NO_x de minimis emission criterion. As previously described (for the diesel generator SO_2 emissions), essentially only local impacts are of concern. The receptors used for diesel generator SO_2 impacts were also used for the NO_2 impact analysis.

Because only annual impacts are at issue for NO_2, the modeling approach for diesel generators and the steam boiler was again based on the hourly screening model results, with post-processing to estimate annual averages (analogous to the way the SO_2 annual averages were obtained.)

All NO_x emissions were initially assumed to be NO_2 which is the standard EPA procedure. Model results with this assumption showed violations of the NAAQS/WAAQS of 100 micrograms/cubic meter. However, this assumption is physically unrealistic because typically less than 10 percent of the NO_x is emitted as NO_2. The remaining 90 percent is NO which will be converted only to the extent that an oxidizing agent (e.g., O_3) is available. Therefore, the NO to NO_2 conversion is limited by the ambient ozone concentration. Consequently, the Ozone Limiting Method (Cole and Summerhays 1979) was employed to provide a more physically realistic assessment of NO_2 impacts. This method separates the predicted NO_x concentrations into two components:

a. Thermal conversion portion - This is the fraction of total NO converted to NO_2 due to the high temperatures of combustion. Most of the conversion occurs prior to exhaust from the stack. It was assumed that 10 percent of the ambient NO_x was thermal-derived NO_2.

b. The remaining stack NO is assumed converted to NO_2 by the stoichiometric reaction with ambient O_3 to the degree that ambient O_3 exists, as expressed by the following:

$$NO + O_3 \rightarrow NO_2 + O_2$$

In other words, if the concentration of ambient ozone is greater than 90 percent of the predicted NO_x concentration, then the resultant predicted NO_2 concentration is assumed equal to the predicted NO_x concentration. However, if 90 percent of the predicted NO_x concentration is greater than the ambient O_3 concentration, then the resultant predicted NO_2 concentration equals 10 percent of the predicted NO_x plus the ambient O_3 concentration.

The most vigorous way to apply this technique is to predict hourly NO_x concentrations and then use concurrent hourly O_3 concentrations to predict conversion of stack NO to ambient NO_2. However, hourly O_3 data does not exist in the Riley Ridge area. The best surrogate is O_3 data collected by WDEQ near Patric Draw (about 10 miles east of Rock Springs -- see Map 1-1). The maximum measured 1-hour average O_3 concentration, 115 micrograms/cubic meter, was used for the entire one-year modeling period. This is clearly conservative.

Northwest's steam boiler also exceeds the NO_x de minimis emission criterion. This source is characterized by moderate stack height (18.3 meters) and moderate buoyancy. Therefore, it may cause impacts both in the near vicinity of the source and at intermediate distances away from the plant. Receptor locations for the annual NO_2 impacts were chosen at the Craven Creek Plant boundary and on a 1-kilometer grid surrounding the plant. Additional receptors were located along 22½° sector directions along the Opal Bench, at 10-meter increments spanning the stable plume centerline elevation range and also at highest terrain elevations that do not reach stable plume centerline. For this source, it was conservatively assumed all NO_x emissions are NO_2.

For the Northern Alternative, combined impacts were explicitly modeled, because of the proximity of the Northwest emission sources at East Dry Basin and the Exxon sources at West Dry Basin.

Modeling of TSP Sources

The principal sources of TSP emissions are the well field diesel generators. All other continuous sources of TSP are negligible by comparison.

Combined diesel generator emissions exceed the TSP de minimis criterion. As described before for the diesel generator SO_2 emissions, essentially only local impacts are of concern. The analysis technique employed for the TSP impact assessment was identical to that used for SO_2 impacts from diesel generators.

Modeling of H_2S Sources

The only sources of H_2S emissions, excluding well blow-outs and pipeline ruptures (Health and Safety section of the EIS), are the Selexol CO_2 vents at all facilities and the nitrogen vents at the Exxon and American Quasar facilities.

The H_2S emitted from each gas treatment plant exceeds the de minimis criterion. These sources are characterized by moderate stacks (100 feet). The Exxon and Northwest plumes have a higher exit temperature, giving them slightly more buoyancy than the Quasar plume. Therefore, at Exxon and Northwest's plants, the plumes are expected to have maximum impact in high terrain surrounding the stacks, whereas American Quasar's plumes would also impact high terrain, although not as high and distant as the Northwest and Exxon plumes. Because of the short averaging time (one-half hour), combined impacts from multiple facilities are not considered possible for the H_2S sources.

Modeling of H_2S emissions followed the protocol established for SO_2 impacts. Both the screening model and sequential calculations were compared against the WAAQS ½-hour standards, with the assumption that 1-hour average concentrations can be compared directly to ½-hour standards. This is justified on the basis that the Pasquill-Gifford-Turner (PGT) Gaussian plume dispersion parameters are conventionally applied for averaging periods of 10 minutes to 1 hour.

Hydrogen sulfide in the CO_2 and nitrogen vent plumes was also modeled using COMPLEX I and hypothetical meteorological conditions to estimate worst-case H_2S odor impacts, particularly in the nearest population centers and in PSD Class I areas. The population centers evaluated include Big Piney, LaBarge, Marbleton, Kemmerer, and Diamondville. The model-predicted 1-hour average H_2S concentrations were compared to a 4.7 parts/billion (6.5 $\mu g/m^3$) H_2S odor threshold value (see the significance criterion in the Introduction to Chapter 2).

Modeling of CO_2 Sources

Carbon dioxide will be vented to the atmosphere until a CO_2 market is found. The principal sources of CO_2 emissions are the CO_2 vents, the nitrogen vents, and the tail gas incinerators. (Note that there is no de minimis criterion for CO_2 emissions.) All other continuous sources are negligible by comparison. Because tail gas incinerator plumes are characterized by tall stacks and buoyant plumes, their maximum ground level impacts would occur well beyond plant boundaries. Since the objective of this analysis was to determine whether concentrations would meet the TLV criteria in the worker environment, tail gas emissions were not evaluated. The CO_2 and nitrogen vent plumes were modeled. Their characteristics are described previously in the H_2S section.

The modeling approach for CO_2 sources followed the protocol established for annual average SO_2. The rationale for this averaging time is provided in the significance criteria discussion in the Introduction to Chapter 2.

Modeling of COS Sources

The only sources of COS are the Selexol CO_2 vents, as described previously. The COS emissions at each facility exceed the de minimis emissions criterion. The sources of CO_2 vents have been described before.

The annual average modeling approach for these emissions is identical to that employed for the CO_2 analysis. The short-term average (8-hour) modeling approach employed the Kemmerer Coal hourly meteorological data as described for H_2S.

Modeling of CO Sources

The principal sources of CO emissions are the well field diesel generators and the tail gas incinerators at Northwest's gas treatment facility. (The proposed Exxon and American Quasar plants do not employ the CBA gas treatment process, and therefore, do not have tail gas incinerator CO emissions.) All other continuous CO sources are negligible by comparison.

When combined, the well field diesel generator CO emissions exceed the de minimis criterion. Northwest's tail gas incinerator CO emissions also exceed the de minimis criterion. Source characteristics of the diesel generators and the tail gas incinerator have been described previously (see Modeling of SO_2 Sources).

The modeling approach for the well field diesel generator CO emissions was analagous to that used to estimate short-term SO_2 impacts from these sources; i.e., the same source locations, stack parameters, and receptors were used. Each meteorological condition was modeled as a 1-hour event. Of these predicted "1-hour" concentrations, the maximum was used for comparison against the 1-hour NAAQS and WAAQS. In order to provide a comparison to the 8-hour standards, the maximum 1-hour event was conservatively assumed to persist for 6 of the 8 hours.

The modeling approach for the tail gas incinerator CO emissions at Northwest's proposed facility was identical to the first, or screening, step of the tail gas incinerator SO_2 emissions assessment. As before, to calculate an 8-hour average impact, the maximum predicted 1-hour CO event was assumed to persist for 6 of the 8 hours.

Modeling of Helium Sources

In the absence of a sales market, helium would be released to the atmosphere through the nitrogen vent stacks at each facility which are the only sources of helium emissions. Helium concentrations within these stacks are 116,000 parts/million and 6,000 parts/million at Northwest and Exxon's plants, respectively. Although information about helium concentrations was not provided by American Quasar, it is assumed that their nitrogen vent helium concentration is similar to Exxon's because both facilities propose to use similar engineering processes.

As described in Chapter 2, the TLV for helium is 30,000 parts/million. Hence, it is obvious that Exxon's and American Quasar's helium emissions would not threaten the TLV. However, further analysis was required for Northwest's helium emissions.

Rather than explicitly modeling Northwest's nitrogen vent helium emissions, the minimum dilution factor required to attain the helium TLV was calculated (116,000/30,000 = 3.87). This factor was then compared, using a Gaussian plume centerline formula, to the minimum possible dilution from the nitrogen vent. Assuming minimum wind speed conditions of 1 meter/second, the product of $\sigma_y\sigma_z$ required to dilute the nitrogen vent helium concentration to acceptable levels is $3.87/\pi$, or 1.2 m^2. Since the stack's exit aperture is only slightly smaller, this condition is always met within a few meters of the release.

Modeling of VOC Sources

Although there are numerous sources of VOC associated with the proposed project, the combined emission rate for all sources is less than the de minimis criterion. Therefore, no modeling of VOC sources was performed. Note, however, that VOC emmission were included when modeling potential ozone impacts due to secondary growth.

SECONDARY GROWTH MODELING

The air quality impacts of a population increase in the Kemmerer-Diamondville area would be primarily due to residential space heating, refuse burning, and vehicular exhaust. (For the purposes of this analysis, it is assumed that residential space heating would be done with natural gas and wood.)

The air pollutant concentrations attributable to secondary growth are estimated with a ventilated box model. The equation for a box model is:

$$\chi = \frac{Q}{uA}$$

Where χ = Ground-level pollutant concentration
Q = Pollutant emission rate
u = Mean wind speed
A = Cross-sectional area normal to the ventilating wind defined by the narrowest city side and the mixing height.

The mean annual wind speed is estimated to be 5 meters/second and the Kemmerer-Diamondville area is assumed to have a minimum cross-wind width of 1 kilometer. Other assumptions made are summarized in Table 3-9.

Two concentrations were calculated for each alternative. The worst-case 1-hour concentration was calculated using a 2 meters/second wind speed and a typical winter morning mixing height. Then the annual average concentration for each pollutant was estimated with a 5 meters/second wind speed and the annual average mixing height.

VISIBILITY IMPAIRMENT MODELING

The Level 1 visibility screening analysis is a simple calculation designed to identify those sources that have little potential of adversely affecting visibility in a Class I area. In a Level 1 analysis, three contrast parameters are calculated. C_1 represents the plume-sky contrast due to particulates and NO_2, C_2 is the reduction in sky/terrain contrast by the same pollutants, and C_3 is the change in sky/terrain contrast caused by secondary aerosols. If the absolute value of all these contrast parameters is less than 0.1, then the source passes the Level 1 test.

The major assumptions involved in a Level 1 analysis are:

- Meteorological conditions for maximum impact by particulates and NO_x are stable (Pasquill-Gifford stability category F) light-wind conditions, with 12-hour transport to the Class I area.
- Meteorological conditions for maximum impact by SO_2 are limited mixing, vertically well-mixed plume within a 1,000 meter mixing depth, 2 meters/second wind speed.
- The observer's line of sight is perpendicular to the plume centerline. The distance from observer to plume centerline is half the width of a 22.5° sector. The viewing background is either the horizon sky or a black terrain object on the opposite side of the plume at a distance equivalent to a full sector from the observer.
- There is complete conversion of NO_x emissions to NO_2.
- Scattering and absorption coefficients are based on a wavelength of 0.55 microns.

- The particle size distribution is based on a typical coal-fired power plant equipped with an electrostatic precipitator.
- Secondary aerosol impacts are evaluated at a distance of 350 kilometers from the source. Since sulfate forms slowly, this is the equivalent of two days transport time with an assumed 2 meters/second wind speed.

The input parameters required for a Level 1 analysis include:

- Minimum distance of the source from a Class I area.
- Background visual range.
- Emission rates for particulates, NO_x, and SO_2.

The Proposed Action includes gas treatment plants at West Dry Basin, Big Mesa, East Dry Basin, and Craven Creek. The first three sites are located within a few kilometers of each other in Sublette County. The Craven Creek Site is more than 50 kilometers further south in Lincoln County. The closest mandatory Class I area is Bridger Wilderness, 69 kilometers northeast of East Dry Basin. The two closest proposed Class I areas are Scab Creek Primitive Area (61 kilometers northeast of East Dry Basin) and Fossil Buttes National Monument (39 kilometers west of Craven Creek and 65 kilometers southwest of Big Mesa). The regional background visual range for southwestern Wyoming is 170 kilometers (Latimer and Ireson 1980).

The SO_2, NO_x, and particulate emissions rates modeled for each source are given in Table 3-12.

ACID DEPOSITION MODELING

The acidity of precipitation is most often related to industrial emissions of sulfur and nitrogen oxides. Once released in the atmosphere, these "primary" contaminants can undergo chemical transformations leading to the production of acidic compounds which are dissolved in precipitation. There is concern that the resultant input of acidity to the earth can affect many components of the environment, including soils, water, vegetation, and wildlife. The magnitude and geographical distribution of such environmental effects in a given area are believed to depend on the interaction of numerous factors, including emission strengths of sulfur and nitrogen oxides, atmospheric diffusion characteristics, atmospheric oxidation kinetics, topography, and climatology as well as various soil, water chemistry, and biological characteristics.

For the Riley Ridge Project, there may be potential for increased acidification of sensitive lakes in the high elevations of the Wind River Range due to SO_2 and NO_x emissions from the proposed gas treatment plants and sour gas well field development. Acid deposition has been identified by the U.S. Forest Service as an important Air Quality Related Value (AQRV) in the Bridger and Fitzpatrick Wildernesses (Federal Class I PSD Areas) during the Riley Ridge Project EIS scoping process.

This analysis focuses on potential acid deposition in the Bridger Wilderness. Impacts in the Fitzpatrick Wilderness and Popo Agie Primitive Area are expected to be less severe than Bridger impacts because there is

TABLE 3-12

EMISSION RATES USED FOR LEVEL 1 VISIBILITY ANALYSIS

Applicant	Source	Emission Rate (Lb/Hour) SO_2	NO_x	PM
American Quasar	SCOT Tail Gas Incinerators	1314	0	0
	Steam Boilers	0.06	15.6	1.74
	Dehydration Heaters	0.006	1.5	0.18
Exxon	SCOT Tail Gas Incinerators[1]	345	0	0
	Steam Boilers[1]	0.04	13.4	0.88
	Regeneration Gas Heaters[1]	0.003	0	0.09
	Sulfur Loadout	0.001	0.3	0.02
	Molten Sulfur Storage[1]	0	0	0.22
Northwest	CBA Tail Gas Incinerator	763	3.55	0.23
	Steam Boilers	0.08	18.82	2.05
	Selexol Heaters	0.004	1.59	0.10
	Misc. Plant Heaters	0	0.75	0
	Wellhead Heaters	0.01	1.28	0.16

[1] Doubled for total. Total for Exxon includes both 600-million scfd plants.

substantial doubt as to whether Riley Ridge plumes could advect around or surmount the 13,000-foot plus elevations of the Wind River Range to impact the Fitzpatrick Wilderness. Impacts in other proposed and existing Class I areas, such as Grand Teton and Yellowstone National Parks, the Teton and Washakie Wilderness, and the Scab Creek Primitive Area, are also expected to be less severe. With the exception of Scab Creek, these areas are further removed from the project site and lie along infrequent plume transport trajectories. Scab Creek is adjacent to the Bridger Wilderness and should have similar impacts (but Scab Creek's lower elevations suggest that its watersheds may have greater buffering capacity).

The modeling protocol described below is designed to provide an assessment of potential acid deposition impacts to three of the more sensitive lakes in the Bridger Wilderness. Presumably, if these impacts are tolerable, then impacts to other less sensitive lakes would be acceptable.

DISCUSSION OF ASSUMPTIONS

The acid deposition modeling results presented in this section are based on several assumptions; each are subject to some uncertainty. These assumptions were necessary at the two primary steps in the analysis: 1) the dispersion and deposition modeling, and 2) the water chemistry modeling. In the absence of any verified methodology for assessing acid deposition impacts in the Bridger Wilderness, it was necessary to adopt procedures that are: 1) based on sound physical principles, and 2) designed and implemented in a manner which ensures that uncertainties in the analysis will tend to overestimate (rather than underestimate) the effects of the Riley Ridge Project on the water chemistry of sensitive lakes in the Bridger Wilderness. This conservatism has been incorporated into the analysis techniques as well as in the selection of various input parameters. Accordingly, the results presented in Chapter 2 are thought to represent conservative upper limits for water chemistry changes to sensitive lakes in the Bridger Wilderness. The assumptions used in the two modeling steps are discussed in more detail below.

The principal assumptions in the dispersion and deposition modeling are:

- Use of a Standard Gaussian Model for Regional-scale Applications. The standard Gaussian dispersion model used in this assessment is very conservative when applied to regional-scale modeling. The model assumes straight-line instantaneous transport to a given receptor. There is no accounting for possible changes in atmospheric stability, wind speed, or direction during plume transport to the Bridger Wilderness. If these physical processes were to be accounted for, the most likely result would be a decrease in the magnitude of Riley Ridge Project acid deposition impacts.

- Selection of Appropriate Wind Data. Because the on-site meteorological data being collected are not yet available for the proposed Riley Ridge Project plant site, a stability wind rose from Fort Bridger was selected as the most representative. If the on-site data differ substantially from the Fort Bridger data, it may be necessary to reanalyze the acid deposition impacts. There are two additional limitations to the meteorological data. First, it was necessary to construct a six-month wintertime (October to March) wind rose by weighting of the available seasonal wind roses, as explained previously in Chapter 3. However, this alone should give rise only to a small uncertainty into the analysis. Second, more rigorous computation of the impacts would have required stratification of the wind rose by precipitation. Wet deposition impacts would be calculated using the "precipitating" wind rose and dry deposition impacts would be calculated using the "non-precipitating" wind rose. If these two wind roses varied from the overall wind rose, substantial uncertainty in the results would occur. [For example, it is possible that winds during precipitation events are mostly from the northwest (associated with post-frontal air masses). If this is true, then the wet deposition impacts presented here may be overestimated. On the other hand, wet deposition may be underestimated if precipitation occurs primarily with southwesterly winds.] Unfortunately, a precipitation-stratified wind rose is not yet available for the project areas. The data required to adequately calculate such a wind rose will be available in mid-1983.

- Interpretation of Precipitation Data. The Riley Ridge Project area contains only limited precipitation data from which to extrapolate across the study area. Data from Big Piney and Pinedale are probably adequate to describe geographical precipitation patterns at lower elevations. However, in mountainous terrain such as the Bridger Wilderness, precipitation may have a wide spatial variation due to differences in terrain elevation and exposure. For this study, without precipitation monitoring sites in the Bridger Wilderness, Soil Conservation Service (SCS) snow survey data were used to estimate wintertime precipitation. These data may underestimate actual wintertime precipitation because of snowpack sublimation and other losses. In addition, recent comparisons of streamflow data with the snow survey data indicate the snowpack accounts for only 80 percent of the streamflow (assuming no snowpack losses). In the absence of any unknown water source, this finding indicates the SCS snow survey data may underestimate the snowpack water equivalent. If the precipitation in the Bridger Wilderness is actually higher than shown by these data, the net result may be an underestimation of the wet acid deposition. However, this is offset by the increased volume of water in which to dilute the acid. For this study, the modeling calculations indicate dry deposition plays a more important role than wet deposition (primarily because precipitation is infrequent and not very intense in the area and the scavenging efficiency of snow is less than for rain). Therefore, the dilution should dominate and any underestimation of precipitation should make the snowpack hydrogen ion concentration conservative.

- Selection of Atmospheric Conversion Rates. The model conversion of SO_2 and NO_x to sulfates and nitrates is assumed to follow first-order-transformations. This procedure is generally accepted for SO_2, but NO_x to nitrate conversions are highly nonlinear. Conversions of both SO_2 and NO_x are photochemically driven, with maximum conversion during summer daytime situations. For the wintertime scenario considered here, these rates should be at a minimum and the selected values are reasonably conservative estimates of seasonal values. However, the study findings indicated sulfate and nitrate depositions are of secondary importance in comparison to SO_2 and NO_x deposition. Any errors in conversion rates would have only minor impact on the final results.

- Characterization of Scavenging Efficiencies. The scavenging efficiency of precipitation for various pollutant types is a critical factor in wet deposition. Particulate sulfate and nitrate scavenging was parameterized according to Scott (1978). These washout ratios are theoretically based and should be reasonably accurate estimates. The washout ratios for gaseous SO_2 and NO_x (which are input directly to the model) are reasonably conservative values. Errors in these values should overestimate wet deposition impacts.

- Selection of Dry Deposition Velocities. As stated above, the study findings indicate dry deposition to be the primary source of acid deposition from the Riley Ridge Project. Dry deposition phenomena are poorly understood at this time. Any errors in specification of the dry deposition velocities would likely have the greatest impact on the final results. Even so, the velocities selected, based on modification of annual average rural values to account for the wintertime scenario, should be conservative estimates for two reasons: since vegetation is a primary absorber of gaseous pollutants, dry deposition should be less in the winter; in addition, because a large portion of the watershed above each lake is above treeline, there is little vegetation available for absorption. Therefore, actual dry deposition velocities may be much lower than those used in this analysis.

The major assumptions in the water chemistry modeling are:

- Total Mixing of Lakes. The model assumes all of the lakes studied are totally mixed by spring runoff. It was assumed that the partial pressure of CO_2 is constant and that the well-mixed water is in equilibrium.

- Neutralization of Acidic Species. The modeling techniques used in this study do not specifically account for neutralization of sulfates and nitrates by alkaline compounds except in the lakes. Such neutralization may occur either during plume transport, deposition, or during snowpack runoff. A primary mechanism for neutralization is entrainment of background levels of ammonia from organic reduction and calcium from soil dust. Production and entrainment of both ammonia and calcium is expected to be minimal in the winter because of reduced organic activity and exposure. Undoubtedly, there will be some alkaline compounds (i.e., windblown dust) present in the atmosphere which may be deposited into the precipitation or snowpack and neutralize some of the acid. Also, some neutralizing agents may occur naturally within the soils of the Bridger Wilderness and neutralize some acid compounds before the runoff can reach the lakes.

It has also been assumed that all of the deposited SO_2 and NO_x is converted to acid and acidifies the runoff water.

Accordingly, the lake water chemistry results were presented based upon a range of calculated acid input values from the snowpack runoff of from 100 to 50 percent. The 100 percent acid input represents the worst-case condition and assumes no acid neutralization. The 50 percent acid input case assumes one-half of the maximum possible acid is lost through a combination of ammonia and calcium neutralization in the snowpack and additional neutralization from alkaline species naturally occurring in the soils beneath the runoff.

- Buffering Capability of Lakes. The calculation of pH changes in the sensitive Bridger Wilderness lakes accounted for only a portion of the acidic buffering by the bicarbonate alkalinity present in the lakes. The measured baseline alkalinity values for the Bridger lakes (data gathered by ERT in August and September 1982) are substantially higher than the calculated alkalinity values used in the model assessment.

EMISSIONS SUMMARY

This section summarizes the pertinent emissions and describes their utilization in the acid deposition modeling. A detailed description of the emission sources can be found in the Emission Inventory Development section in this chapter.

Table 3-13 summarizes the SO_2 and NO_x emission sources considered in the acid deposition modeling assessment. Temporary emissions associated with emergency operations (except for flaring) were not considered in this assessment. From the table, it can be seen that SO_2 emissions are primarily associated with plant tail gas incineration and that NO_x emissions are primarily associated with well field drilling operations.

Emissions of reduced sulfur species, i.e., COS and H_2S were ignored because 1) the conversion rate of COS to sulfates in the troposphere is negligible compared to the conversion of SO_2 (Logan et al. 1979), and 2) the H_2S emissions are fairly small).

Temporary flaring of natural gas during plant upset conditions can produce large SO_2 emissions for short time intervals. These emissions may also contribute to acid deposition in the Bridger Wilderness.

Because acid deposition is essentially a long-range transport dispersion modeling problem, precise geographic placement of emission sources is not essential. Therefore, to simplify the modeling exercise, the emissions listed in Table 3-13 were assumed to emanate from two points. For the Proposed Action, one point was located midway between the Big Mesa, West Dry Basin, and East Dry Basin plant sites. Emissions from the American Quasar and Exxon gas treatment plants as well as all well field operations were placed at this location. The other point was located at the proposed Craven Creek site. Northwest's gas treatment plant emissions and Exxon's sulfur loadout emissions were placed at this site. Source placement was adjusted

TABLE 3-13

ACID DEPOSITION MODELING EMISSIONS INVENTORY

Company	Source	SO_2 Emissions (tpy)	NO_x Emissions (tpy)
Northwest Pipeline	CBA Tail Gas Incinerator	3,342	0
	Steam Boilers	0.4	82.4
	Selexol Process Regeneration Heater	0	3.5
	Miscellaneous Plant Heaters	0	1.6
	Plant Flaring	126.8	0
Mobil Oil	Drilling Operations	15.3	229.9
	Wellhead Heaters	0	0.6
	Well Field Flaring	203.7	0
American Quasar	Steam Boilers	0	2.6
	Dehydration Heater	0	3.3
	SCOT Tail Gas Incinerator	5,747	0
	Drilling Operations[1]	184	2,796.8
	Plant and Well Field Flaring	810	0
Exxon	SCOT Tail Gas Incinerator	3,020	0
	Intermittent Steam Supply	0	35.4
	Regeneration Gas Heater	0	6.2
	Drilling Operations	69	1,048.8
	Sulfur Loadout	0	1.3
	Plant Well Field Flaring	-	0

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[1] Includes Williams Exploration.

for each alternative accordingly. Stack parameters representative of the tail gas incinerator stacks (the primary sources of SO_2) were used in the acid deposition modeling. However, plume rise (a function of the stack parameters) is not very critical here because of the long-range transport and the resultant mixing in the vertical.

LAKE CHARACTERIZATION

The acid deposition modeling analysis focuses on three acid-sensitive lakes located high in the Bridger Wilderness. If the impacts to these lakes are tolerable, presumably the impacts to other lakes would also be tolerable. The principal concern in this assessment relates to "acid shock" from spring runoff of the accumulated snowpack rather than to annual average acid loading effects. This period corresponds to the spawning period of golden trout and other trout species in the lake inlets and outlets during June and July. This has been identified in the EIS scoping process as the principal biological concern.

The lakes selected satisfy the following criteria:

- The lakes are downwind of the Riley Ridge Project area, in directions corresponding climatologically to prevailing winds during the months of snowpack accumulation.
- The lakes are situated in granitic formations of very low buffering capacity.
- The lakes selected are of relatively low volume so that total mixing of the lake by the spring runoff can be assumed.

The three lakes in the Bridger Wilderness identified by the Forest Service in the scoping process as sites for future water quality sampling programs are:

- Clear Lake (North) at 8,800 feet elevation, about 50 kilometers northeast-east of Pinedale and immediately north of Flat Top Mountain.
- Clear Lake (South) at about 10,000 feet elevation, about 60 kilometers southeast of Pinedale and 5 kilometers southeast of Bunion Mountain.
- Hobbs Lake at about 9,100 feet elevation, 25 kilometers northeast of Pinedale.

PRECIPITATION INPUTS

A critical input to the acid deposition modeling analysis is the precipitation data. In order to effectively account for acid deposition at the critical lakes, the analysis must also account for pollutant deposition from dry and wet processes during transport from the Riley Ridge Project area to the Bridger Wilderness. This requires knowledge of the geographic distribution of wintertime precipitation. The frequency of precipitation and its form (as rain or as snow) is also important because precipitation rate rather than total precipitation is the critical factor in calculating the acid deposition flux.

Climatological data from which to gather these inputs is scarce in the Riley Ridge area. Local National Weather Service (NWS) climatological stations comprise the primary data base, but these stations are typically located at lower elevations and may not be representative of high terrain areas such as the Bridger Wilderness Area. Precipitation at high elevations was therefore estimated from SCS snow survey data. For the wintertime scenario under consideration here, these data are considered adequate, although the total precipitation is likely to be slightly underestimated because of snowpack sublimation over the winter period.

NWS local climatological data are available from two sites in the Riley Ridge area: 1) Big Piney, slightly northeast of the project area; and 2) Pinedale, at the base of the Wind River Range and northeast of the project area. SCS snow survey data are available for five sites in the area of the lakes under study: 1) New Fork Lake, 2) Elkhart Park, 3) Pocket Creek, 4) Big Sandy, and 5) Larsen Creek. Table 3-14 presents monthly wintertime precipitation amounts for Big Piney and Pinedale and late spring snowpack water equivalent measurements from the SCS data. The NWS data represent 30-year climatological means (1941-1970) and the SCS data represent 15-year means (1963-1977). This table shows the strong dependence of total winter precipitation on elevation.

Total wintertime precipitation at the three critical lakes was estimated from the precipitation vs. elevation relationship. A least-squares best fit line was developed from the precipitation and elevation data from the five SCS sites and Pinedale (see Figure 3-1). This line indicated a strong linear correlation (correlation coefficient = 0.97) between precipitation and elevation in the Bridger Wilderness. The total wintertime precipitation at the critical lakes was estimated from this graph based on the lake elevation. These data were then converted to precipitation rates by consideration of the frequency of precipitation. Frequency data are not included in the SCS data, but are routinely included in the NWS data sets. Precipitation rates in the mountains were assumed to be about 20 percent higher than at Pinedale and Big Piney.

ACID DEPOSITION MODEL

NO_x and SO_2 emissions from the Riley Ridge Project would be transformed to nitrate (NO_3^-) and ($SO_4^=$) at rates that depend on insolation, meteorological conditions, and other chemical constituents present in the plume and atmosphere. The natural dry deposition of primary and secondary species at the surface varies with the contaminant species and vegetation type. Natural wet removal during precipitation occurs by nucleation, in-cloud scavenging ("rainout"), and below-cloud "washout". The source depletion model for acid deposition is a "climatological-type" Gaussian plume model that has been modified to account for these removal processes and to compute wet and dry deposition fluxes.

To include chemical transformations and surface deposition, the model first calculates ambient concentrations in the conventional way, assuming no depletion by chemical reactions or surface deposition. These resulting

TABLE 3-14

WINTERTIME PRECIPITATION AND SNOWPACK DATA

Station and Elevation (feet)		Precipitation (inches H_2O equivalent)						
		October	November	December	January	February	March	Winter Total
Big Piney	6,970	0.65	0.44	0.46	0.37	0.33	0.41	2.66
Pinedale	7,175	0.84	0.89	0.91	0.73	0.59	0.63	4.59

Station	Elevation (feet)	Location	Snowpack Water-Equivalent (inches)
New Fork Lake	8,340	T36N R110W Sec 11	11.8
Elkhart Park	9,400	43°00'N 109° 45'W	15.4
Pocket Creek	9,350	42°42'N 109° 25'W	14.1
Big Sandy	9,080	T31N R104W Sec 21	14.8
Larsen Creek	9,020	42°36'N 109°05'W	12.9

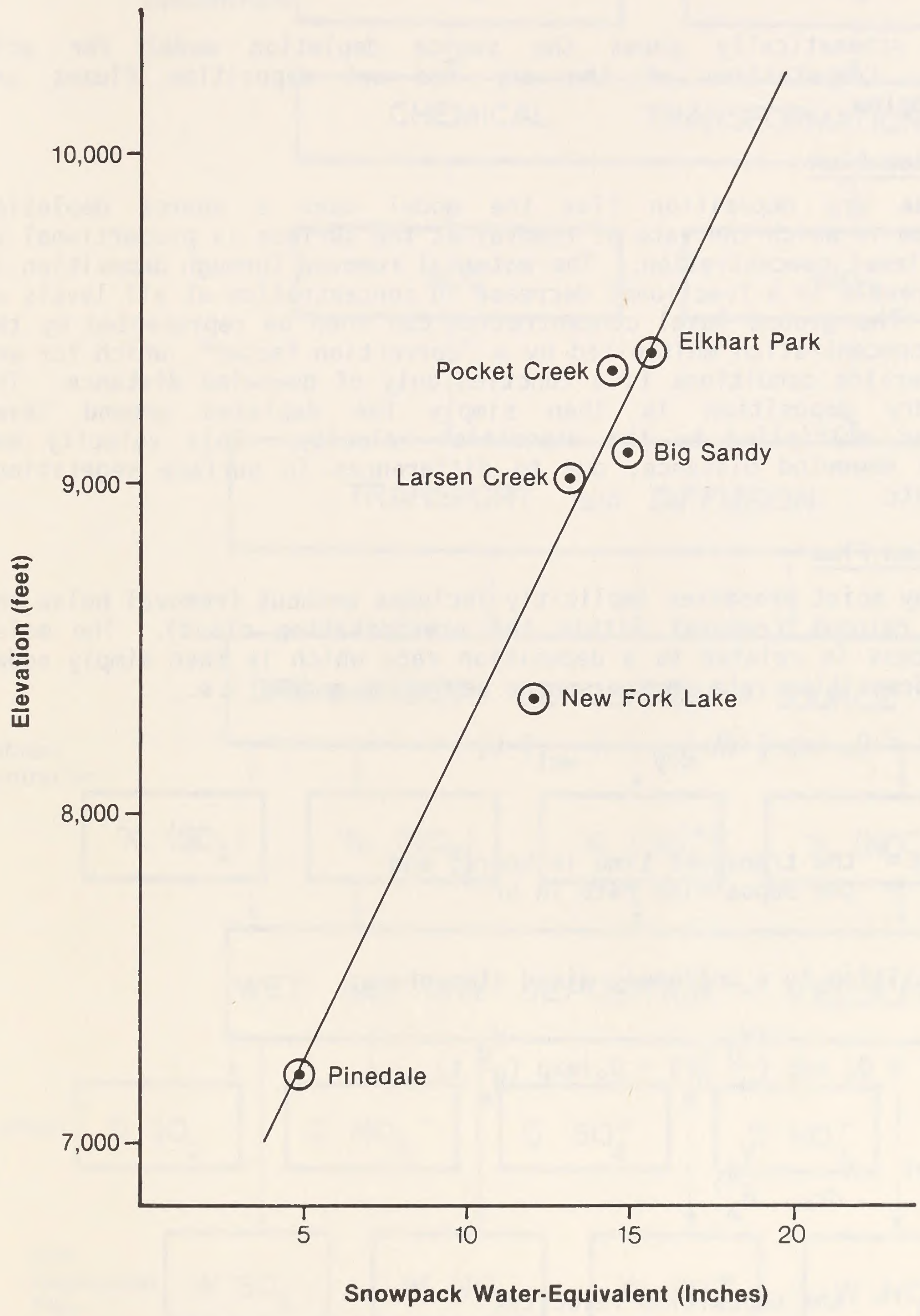

FIGURE 3-1 CORRELATION OF WINTER PRECIPITATION WITH ELEVATION

concentrations are then multiplied by "effective emission" (or equivalently, "effective source depletion") rates which account for the depletion processes.

Figure 3-2 schematically shows the source depletion model for acid deposition. Computations of the dry and wet deposition fluxes are summarized below.

Dry Deposition Flux

To calculate dry deposition flux the model uses a source depletion approximation in which the rate of removal at the surface is proportional to the ground level concentration. The material removed through deposition is assumed to result in a fractional decrease in concentration at all levels of the plume. The ground level concentration can then be represented by the undepleted concentration multiplied by a "correction factor", which for any set of dispersion conditions is a function only of downwind distance. The rate of dry deposition is then simply the depleted ground level concentration multiplied by the deposition velocity. This velocity may change with downwind distance, due to differences in surface vegetation, roughness, etc.

Wet Deposition Flux

Deposition by moist processes implicitly includes washout (removal below the cloud) and rainout (removal within the precipitating cloud). The moist removal process is related to a deposition rate which is then simply added to the dry deposition rate in the source depletion model, i.e.,

$$Q' = Q_o \exp\left[-(\lambda_{dry} + \lambda_{wet})\, t\right]$$

Where

t = the transport time in hours, and

λ = the deposition rate in hr^{-1}

For dry deposition in a uniformly mixed atmosphere:

$$Q' = Q_o \exp\left(\frac{-V_d}{u}\frac{x}{H_m}\right) = Q_o \exp\left(\frac{-V_d}{H_m}\, t\right)$$

$$\left(\text{so that}\quad \lambda_{dry} = \frac{V_d}{H_m}\right)$$

Where

V_d = the deposition velocity,

H_m = the mixing depth,

u = the wind speed, and

x = the downwind distance

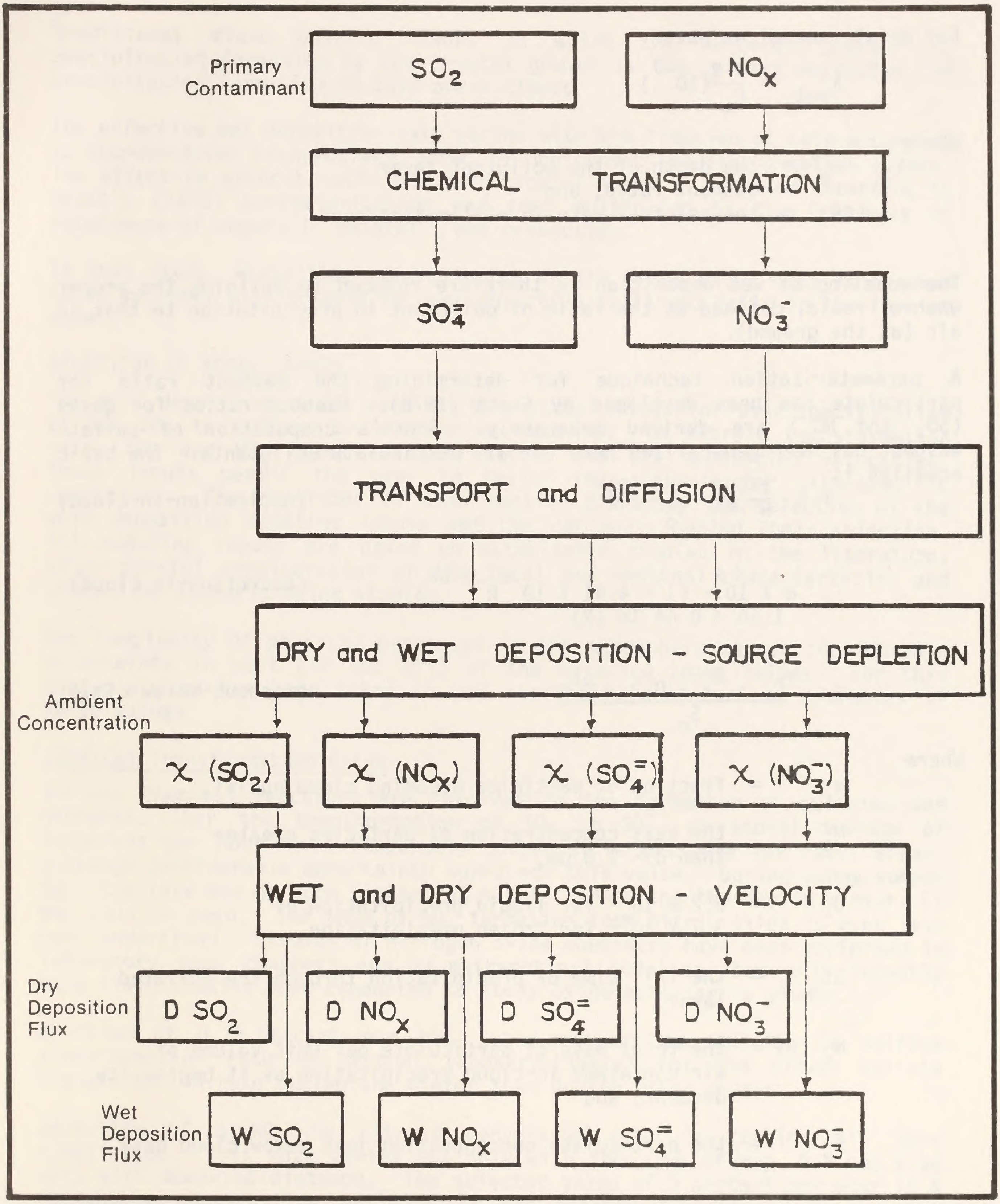

FIGURE 3-2 SOURCE DEPLETION MODEL.

For moist removal we have:

$$\lambda_{wet} = \frac{r \cdot R}{H_m}(10^{-3})$$

Where

H_m = the depth of the pollutant layer
r = washout ratio, and
R = the rainfall rate in millimeters/hour

The modeling of wet deposition is therefore reduced to defining the proper washout ratio, defined as the ratio of pollutant in precipitation to that in air (at the ground).

A parameterization technique for determining the washout ratio for particulate has been developed by Scott (1978). Washout ratios for gases (SO_2 and NO_x) are derived separately. Scott's computation of sulfate washout has been generalized here for all particulate pollutants. The basic equation is:

$$r = \frac{14000 \cdot Ms\ (0)}{R^{0.88} \quad S_o} \qquad \text{(nucleation-in cloud)}$$

$$+ \frac{\alpha \times 10^{3} \cdot (1 - 4.41 \times 10^{-2} R^{-0.88})}{1.56 + 0.44 \ln (R)} \qquad \text{(accretion-in cloud)}$$

$$+ \frac{C_1 \cdot M_a \cdot 0.3 \cdot \Delta t_b}{S_o} \qquad \text{(washout-below cloud)}$$

Where

α = fraction of particles becoming cloud nuclei,

M_a = the mass concentration of particles greater than $d \sim 1.0\ \mu m$,

C_1 = 5.2×10^{-3} for liquid precipitation or 3.7×10^{-3} for frozen precipitation,

Δt_b = the fall time of precipitation through the polluted layer,

$M_s\ (0)$ = the total mass of particulate per unit volume of air contained in-cloud precipitation as it begins its descent, and

S_o = the particulate concentration just below cloud base.

In the equation above, the first term represents in-cloud nucleation; the second term represents in-cloud accretion; and the third term represents below-cloud washout. For cold wintertime clouds (like those representative of the Riley Ridge Project area), Scott (1978) sets $M_s(0) = 0$ to indicate no cloud droplet formation by nucleation. This is entirely consistent with traditional cloud physics theory in which the Bergeron process of precipitation formation by ice crystal growth is the primary mechanism for precipitation formation in cold phase clouds.

The effective wet deposition rate varies with the fraction of rain occurring in thunderstorms (convective), snow, or non-convective precipitation events. The effective washout ratio for each type of event is computed according to Scott's (1978) parameterization and then multiplied by the frequency of occurrence of snowfall, rainfall, and convection.

In this study, wintertime precipitation in the Riley Ridge area is assumed to be entirely attributable to non-convective cells and falls in the form of snow.

SELECTION OF MODEL INPUTS

The acid deposition model used in this study allows for user specification of the SO_2 to sulfate transformation rate, NO_x to nitrate transformation rate, SO_2 and NO_x (gas) washout ratios, and dry deposition velocities. These inputs permit the user to tailor the analysis for site-specific conditions. The remainder of this section discusses the selection of the acid deposition modeling inputs and the rationale behind their selection. All modeling inputs are based on established studies in the literature, after careful consideration of the local and regional characteristics and wintertime scenario being studied.

The complexity of physical processes in the atmosphere causes considerable uncertainty in most (if not all) of the selected input values. For this analysis care has been taken to use reasonably conservative estimates of these values.

Chemical Transformation Rates

Various chemical reactions are involved in the formation of sulfates and nitrates. For the transformation of SO_2 to $SO_4^=$, an annual average of 1 percent per hour is a reasonably conservative estimate for rural areas, although considerable uncertainty surrounds this value. During sunny summer days the rate may be much higher; at night, and during the day in winter, it may fall to zero. The rate of NO_3 formation from nitric oxide is even less well understood. Studies of nitrogen oxide chemistry have been performed in laboratory smog chambers and by mathematical modeling, but only recently have field studies been conducted to study oxide behavior in plumes.

A value of 0.75 percent per hour was selected as the SO_2 to sulfate transformation rate to account (conservatively) for the slower sulfate transformation rate during the winter than during other seasons.

Selection of a NO_x to nitrate conversion rate is considerably more complicated. This rate varies not only with the time of day, but may also vary with downwind distance. The selected value of 5 percent per hour is a reasonably conservative estimate of the nitrate formation rate for the wintertime scenario under consideration.

Washout Ratios

The source depletion model uses washout ratios to describe the wet depositon flux of gaseous and particulate material. The washout ratios for particulate (sulfate and nitrate) are calculated according to the parameterization of Scott (1978) described previously. Gaseous (SO_2 and NO_x) washout ratios are user-specified inputs to the model.

The removal of gaseous contaminants by precipitation is a complex process, governed by background ambient pollutant concentrations, precipitation type, rate, and pH. The source depletion model accounts for wet gaseous removal by below-cloud washout. Empirical washout coefficients have been derived to predict the scavenging of gaseous contaminants during below-cloud washout. For this study, the gaseous washout ratios (the ratio of gas concentration in precipitation to gas concentration in air) are assumed to be 10^5 for SO_2 and $2 \cdot 10^5$ for NO_x based on the values published by Slinn (1982). The larger value for NO_x accounts for the finding that NO_x impacts in the winter are of the same magnitude as SO_2 impacts. Since SO_2 deposits twice as many hydrogen ions per molecule than does NO_x, the gaseous washout contributions using these inputs should be about equal.

Dry Deposition Velocities

The dry deposition of a contaminant onto the ground or vegetative surface depends on its ground-level ambient concentration and the retentive ability of the surface. A "deposition velocity" is often used as an empirical measure of this capability. Gases are deposited because of absorption by surface vegetation or by chemical reactions which take place on wet surfaces. For particles, dry deposition is the result of turbulent and gravitational transport to the surface and subsequent impaction onto collectors. Vegetation is the most efficient collector for particles less than 10 microns in diameter.

Typically, reactive gases such as SO_2 and NO_x, which can be readily taken up into groundwater or vegetation, are assumed to have an annual average deposition velocity of about 1 centimeter/second. However, during the winter in the Riley Ridge area, the ground is usually snow covered. This will tend to reduce the potential for dry deposition of SO_2 and NO_x. Taking this into consideration, a dry deposition velocity of 0.75 centimeters/second was assumed for SO_2 and NO_x in this study. This value is considered conservative for the scenario being studied.

For particulate sulfate aerosols, which are in the 0.1 to 4.0 micron range, typical dry deposition velocities range from 0.2 to 1.0 centimeters/second. The lower value is appropriate for smooth surfaces with no vegetation. For this study, a reasonably conservative value of 0.5 centimeters/second has been assumed for both sulfate and nitrate dry deposition.

CALCULATION OF pH CHANGES

A comprehensive, well-validated model that quantitatively relates acid deposition to changes in the pH of water bodies is yet to be developed. Such a model would require input information about: rainwater composition; atmospheric concentrations of acidic and alkaline species; efficiency of hydrogen ion removal by specific vegetation types; chemical analysis of soils and groundwaters; weathering rates of rocks and minerals; buffering capacity of soils; size of drainage areas; volumes of water bodies; stratification of lakes; water quality data; precipitation rates and scavenging efficiencies.

Without such a comprehensive model or the detailed data it would require, simplifying assumptions and approximations were made following established chemical and physical principles. A simple scheme was developed to relate the deposition of acidic species to springtime changes in the pH of sensitive lakes in the Bridger Wilderness. This scheme was selected on the basis of the available type and quantity of information, the characteristics of the water bodies, and the time period of interest.

The primary simplification in this analysis is assumption of a well mixed lake. In effect the model assumes the worst-case pH change results when equal volumes of acidic runoff and original lake water have completely mixed with outflow equal to inflow during the mixing period.

The H^+ concentration in the snowpack is calculated using the source depletion model. To maximize the H^+ input (for a conservative estimate of largest possible pH change) the SO_2 and sulfate are treated as sulfuric acid (H_2SO_4), and the NO_x and nitrate as nitric acid (HNO_3). (The NO_x is treated as NO_2 in the source depletion model.) The deposition fluxes of SO_2, sulfate, NO_2, and nitrate (expressed as grams/square meter/unit time) are divided by their equivalent weights (respectively 32, 48, 46, and 62 grams/equivalent H^+) to convert to equivalents (eq) of hydronium ion/square meter/unit time.

Because complete mixing has been assumed, the H^+ input to the lake is considered to be governed entirely by the H^+ concentration of the runoff water. This latter value can be estimated by: A) Calculating the total seasonal deposition of $[H^+]$ into the snowpack, and B) Dividing by the equivalent liquid water content of the snowpack to obtain $[H^+]_{in}$ in equivalents per liter (eq/l).

The lake pH change resulting from the interaction of the incremental $(H^+)_{in}$ with the existing water quality was calculated using a simple scheme in which the acid input is neutralized only by the inorganic carbonate ($H_2CO_3/HCO_3^-/CO_3^=$) system's contribution to the total measured lake alkalinity. (This treatment is probably conservative with respect to acid neutralizing capability in that only a fraction of the measured buffering capacity of the surface water was used to neutralize the strong acid input $(H^+]_{in}$.)

One can use the equilibrium laws that govern the acid-base behavior of the carbonate system as the starting point for the derivation of the necessary equations which estimate the amount of inorganic bicarbonate available assuming the lake is in equilibrium with atmospheric CO_2:

$$K_H = \frac{[H_2CO_3^*]}{P_{CO_2}} = 10^{-1.5} \qquad (1)$$

$$K_1 = \frac{[HCO_3^-]\,[H^+]}{[H_2CO_3^*]} = 10^{-6.3} \qquad (2)$$

Where

$[H_2CO_3^*] = [H_2CO_3 + CO_2 \text{ (aqueous)}]$

P_{CO_2} = partial pressure of CO_2 in the atmosphere $\approx 10^{-3.5}$ atm

and the equilibrium constants K_H, K_1 are nominal values.

Equations 1 and 2 can be combined as

$$[H^+] = \frac{K_1 K_H P_{CO_2}}{[HCO_3^-]}$$

Taking the negative logarithms of both sides and substituting the numerical values of K_H and K_1 we get:

$pH = 11.3 - pHCO_3^-$,

from which we obtain $[HCO_3^-]$. In deriving the above, it was assumed that the general alkalinity expression:

$[Alk] = [HCO_3^-] + 2[CO_3^=] + [OH^-] - [H^+] = [HCO_3^-]$ only,

because in the pH range 5-9 the terms $[CO_3^=]$, $[OH^-]$, and $[H^+]$ are very small relative to $[HCO_3]$. (However, if the pH is less than 5, the $[H^+]$ term cannot be ignored.)

In effect, use of the above equations is a method for estimating the amount of inorganically-derived bicarbonate alkalinity available in the lake in the absence of specific measurements of inorganic bicarbonate.

To calculate the pH change, the strong acid input is subtracted from the calculated bicarbonate alkalinity:

$[HCO_3^-]$ (reduced) = $[HCO_3^-]$ (originally calculated) - $[H^+]$ (from snowmelt)

and the "new" pH value is computed from the reduced bicarbonate alkalinity by reversing the calculation.

In practice this must be done iteratively, because the difference between old and new pH values means an increase in free hydrogen ion concentration, so the amount of strong acid input used to titrate the bicarbonate alkalinity should be decreased by the amount of free hydrogen ion made available. The iteration should be repeated until the strong acid input is appropriately proportioned between titrating the alkalinity and increasing the free H^+ concentrations. For our purposes, however, the process usually converges very rapidly.

Let us illustrate this scheme with a simple example. Suppose a hypothetical lake has the following measured pH and alkalinity values:

$pH = 7.0$

$[Alk] = 100\ \mu eq/l$

and we wish to predict the pH change resulting from the addition of 20 μeq/l of $[H^+]$ to the lake on an annual basis. We have $pHCO_3 = 4.3$ or $[HCO_3] = 50.1\ \mu eq/l$, roughly one half of the measured alkalinity. Because the remaining 49.9 μeq/l of alkalinity is not chemically quantified, we cannot accurately account for its acid neutralizing capability. Therefore, only the bicarbonate alkalinity will be used to neutralize the $[H^+]_{in}$; thus $[HCO_3]_{new} = 50.1 - 20 = 30.1\ \mu eq/l$, or $pH\,[HCO_3]_{new} = 4.52$. We then obtain $pH_{new} = 11.3 - 4.52 = 6.78$, so $\Delta pH = 7.0 - 6.78 = 0.22$.

This change in pH corresponds to an 0.07 μeq/l increase in free hydrogen ion concentration (from 0.10 to 0.17 μeq/l), so, strictly, the amount of strong acid input should be reduced by 0.07 μeq/l and the pH should be recalculated. In this example the further change is negligible.

Note that this simple conservative scheme ignores neutralization by dissolved atmospheric ammonia, organic, and inorganic carbon, soil-derived calcereous material, and other alkaline materials.

MODELING OF CONSTRUCTION-RELATED IMPACTS

During construction of the gas treatment plants, access roads, sulfur loadout, well field sites, and various pipelines, the pollutant of concern is TSP due to fugitive particulate emissions. For each of these activities, estimates of fugitive particulate emissions have been calculated (see Chapter 2 for summaries and Appendix 1 for detailed calculations).

Of the five types of construction activities related to this project, only stationary operations were considered for modeling, i.e., construction of gas treatment plants, the sulfur loadout, and well field sites. Even though emissions estimates for pipeline construction are greater than some stationary operations, the potential TSP impacts from pipeline construction would be less, because the fugitive dust emissions sources would move as the pipe is installed. Access road construction, the other type of construction activity related to this project, is also a non-stationary source of TSP emissions. Furthermore, with the exception of the Buckhorn Site, estimated TSP emission rates due to access road construction are negligible in comparison to other fugitive dust sources. Consequently, the access road emissions were included only when modeling the Buckhorn site plant construction.

Although these sources are temporary and, therefore, not subject to PSD requirements, compliance with the NAAQS and WAAQS must be determined. The modeling methodology employed for this determination follows WDEQ requirements, since that agency has permit authority for this project. Although a 24-hour TSP standard exists, WDEQ believes that presently available fugitive dust modeling techniques are not reliable for these short-term impact assessments. Hence, the analysis of construction-related fugitive particulate impacts compliance with ambient air quality standards is based upon calculations of annual average TSP concentrations. The EPA model ISC was selected for these impact estimates because ISC is acceptable to WDEQ, ISC employs a particulate deposition algorithm, and ISC (long-term version) calculates annual averages. The Fort Bridger Wyoming STAR meteorological data were used for all such modeling, and receptors were places no closer than 200 meters from any source.

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GLOSSARY

ACID SHOCK. A highly concentrated "slug flow" of acid runoff into a lake or stream which usually occurs during the early stages of snowmelt. Soluble impurities in the snow cause the freezing point of water to drop below 0°C, allowing the snowpack acidic material to melt first.

ALKALINITY. The ability of a lake or stream to neutralize acid input.

ALLOWABLE EMISSIONS. The maximum emission rate of a source which is permitted by regulation. In general, source emission rates are below the allowable emission level.

ASSUMED WORST-CASE METEOROLOGY. An assumed set of meteorological conditions input to a dispersion model. These conditions typically represent the worst possible dispersion condition, without regard for actual frequency or persistance. They are commonly used in areas where on-site data is unavailable. Worst-case meteorology tends to yield much higher impacts when compared to more representative on-site data.

BACKGROUND CONCENTRATION. The existing levels of air pollutant concentrations in a given region. In general, it includes natural and existing emission sources, but not future emission sources.

BOX MODEL. A simple dispersion model in which pollutants are uniformly distributed throughout the volume of the "box".

CLASS I AREAS. Specified areas (generally comprising National Parks and Wilderness) where future deterioration of air quality is severely limited.

CLASS II AREAS. Specified areas (comprising most areas currently attaining air quality standards) where moderate deterioration of future air quality is allowed.

DE MINIMIS EMISSION LEVELS. This term refers to emission levels specified in the EPA PSD Regulations (40 CFR Part 52.21). Source emissions below this level are exempted from several PSD requirements because they result in very small air quality impacts.

EPA SIGNIFICANCE LEVELS. The maximum permitted increase in pollutant concentrations within a nonattainment area from a new source.

FUGITIVE DUST. Air emissions of particulate matter which are not vented through a stack, hood, or similar device. In general, fugitive dust is comprised of large particles which fall out very quickly, thereby limiting the area of impact to the immediate vicinity of the source.

GAUSSIAN DISPERSION. A theory of atmospheric dispersion which states that vertical and/or horizontal pollutant concentration profiles are described by Gaussian (or normal) distributions. Pollutant concentrations at any point can then be described by the standard deviation of these distributions (called dispersion coefficients), which are a function only of downwind distance and the local meteorology.

HIGHEST SECOND HIGHEST. The highest concentration remaining in the set of concentrations at all receptors or measuring stations after the maximum concentrations at all receptors or measuring stations have been disregarded. This value is often used to determine compliance with short-term NAAQS, WAAQS, and PSD increments.

IMPACT AREA. A circular area surrounding a plant with a radius equal to the maximum distance to which concentrations equal to the EPA Significance Levels are modeled.

KATABATIC WIND. Any wind blowing down an incline.

MIXING HEIGHT. The height above ground-level to which pollutants can disperse in the vertical.

MULTIMEDIA ENVIRONMENTAL GOAL. Levels of chemical contaminants in the ambient air which will not produce known negative effects in exposed human populations or ecosystems. These goals were derived by EPA. However, they do not carry the force of ambient standards or regulations.

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS). A set of EPA standards regulating the maximum allowable concentrations of air pollutants permitted in the United States. Primary standards protect the public health; secondary standards protect the public welfare. Standards are in force for SO_2, TSP, NO_2, O_3, CO, and lead.

NONATTAINMENT AREA. An area in which one or more NAAQS/WAAQS is being violated.

OZONE LIMITING METHOD. A model for calculating NO_2 concentrations (Cole and Summerhays 1979) in which conversion of NO to NO_2 is limited by the available ambient ozone concentrations.

PILOT BALLOON. A small balloon whose ascent is tracked to determine the wind speed and direction at various altitudes above a station.

pH. The acidity of a solution measured on a scale of 0 to 14, with 7 representing neutrality. Values less than 7 indicate acidity; values greater than 7 represent alkalinity. This value is calculated by taking the negative logarithin (base 10) of the effective hydrogen ion concentration measured in equivalents per liter.

PSD INCREMENTS. The maximum allowable increase in pollutant concentrations permitted over baseline conditions as specified in the EPA Prevention of Significant Deterioration (PSD) regulations (40 CFR Part 52.21). The regulations apply only to areas currently attaining WAAQS/WAAQS. Most National Parks and Wildernesses are Class I Areas, where almost no future pollution increase is permitted. Most other areas are Class II Areas, where a moderate increase in pollution levels is allowed.

RADIOSONDE. A balloon-borne instrument for the simultaneous measurement and transmission of pressure, temperature, and humidity data. These instruments are often used to measure atmospheric vertical temperature profiles. If coupled with an automatic tracking device to measure wind speed and direction, the instrument is sometimes referred to as a "rawinsonde".

SCFD. Standard cubic feet per day.

SECONDARY GROWTH. Increases in air pollutant emissions resulting not from the project directly, but from increases in population attributable to the project (employees, families, etc.). Emissions are primarily from residential space heating (natural gas, coal, or wood) and vehicle usage.

STABILITY CLASS. A measure of atmospheric stability or dispersion potential in the atmosphere. Usually divided into 6 classes (A through F), where A represents the most unstable and F represents the most stable.

STAR DATA. A tabular stability/wind frequency distribution commonly used as input to long-term average dispersion models.

SYNOPTIC. Regional scale.

THRESHOLD LIMIT VALUES (TLV). Concentrations of pollutants established by the American Council of Governmental Industrial Hygienists (ACGIH) which represent conditions to which workers may be repeatedly exposed day after day without adverse effect.

TRONA. A grey-white or yellow-white monoclinic mineral [$Na_3H(CO_3)_2 \cdot 2H_2O$] consisting of hydrous acid sodium carbonate.

VISUAL RANGE. The distance at which a black object (in practice, a distant mountain) becomes indistinguishable to an observer.

WIND ROSE. Any one of a class of diagrams designed to illustrate the distribution of wind direction experienced at a given loaction over a given period of time. Wind roses may also give information concerning distribution of wind speed, stability, or other meteorological parameters.

WYOMING AMBIENT AIR QUALITY STANDARDS (WAAQS). Analagous to the NAAQS, except established by the Wyoming Department of Environmental Quality to regulate pollutant concentrations in Wyoming.

APPENDIX 1

FUGITIVE DUST EMISSION CALCULATIONS
CONSTRUCTION ACTIVITIES

FUGITIVE DUST EMISSION INVENTORY GLOSSARY

EF - Emission Factor
UER - Uncontrolled Emission Rate
CER - Controlled Emission Rate
VMT - Vehicle Miles Traveled

EXXON CONSTRUCTION FUGITIVE DUST ESTIMATES

1. Gas Sweetening Plant Construction

EF = 1.2 tons/acre month (AP-42)

Correct the emissions factor for the number of rainy days/year (estimated at 100 days - from map in AP-42)

EF = (1.2 tons/acre-month) (265 dry days/365 days per year)
= 0.87 tons/acre-month

Each 200 MMSCFD module consists of approximately 53 acres (160 acres/3 modules)

Overall site leveling and grading for each 160 acre site (consisting of 3 modules) takes place during the initial 4 months of construction. The West Dry Basin site will be graded during 1984. The Big Mesa site will be graded during 1988. Subsequent construction takes approximately 2 months per module according to the schedule below.

Module	Location	Construction Period for Subsequent Development
1	West Dry Basin	Mid 1984
2	West Dry Basin	Mid 1985
3	West Dry Basin	Mid 1987
4	Big Mesa	Mid 1988
5	Big Mesa	Mid 1989
6	Big Mesa	Mid 1991

UER (grading) = (0.87 tons/acre month) (160 acres/site) (4 months/year)
= 557 tons/site-year

UER (subs. dev) = (0.87 tons/acre month) (53 acres/module) (2 months/year)
= 92 tons/module-year

Assume watering for dust control of 50% (AP-42)

UER (Tons/Year)

Year	Grading	Modules	Total	Total CER (tons/year)
1984	557	92	649	325
1985	0	92	92	46
1986	0	0	0	0
1987	0	92	92	46
1988	557	92	649	325
1990	0	0	0	0
1991	0	92	92	46

2. Access Roads Construction and Maintenance

EF = 32 lb/hour (Wyoming DEQ)
for graders or scrapers

Construction during 1984 - 1993 (10 years)
During months of April - October (7 months/year)

140 miles of access roads to the well sites
68 miles require maintenance
27 miles of new roads
46 miles of roads require upgrading and maintenance

Assume average grader/scraper speed is 5 miles/hour
Assume 4 graders/scrapers work on one section at once for construction
Assume 1 grader works on 1 section during maintenance and roads are graded once/month

EF = (32 lb/scraper hour) (hour/5 miles) (4 scrapers)
= 25.6 lb/mile (construction)

EF = (32 lb/scraper hour) (hour/5 miles) (1 scraper)
= 6.4 lb/mile (maintenance)

UER (construction) = (25.6 lb/mile) (27 miles/10 years) (ton/2000 lb)
= 0.03 tons/year

UER (Maintenance) = (6.4 lb/mile) (140 miles) (7 times/year) (ton/2000 lb)
= 3.1 tons/year

Emissions are for years 1984 - 1993

3. Gas Gathering System (pipe laying)

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth of 1.0 feet

108 miles of pipe, ROW = 100 feet

Construction years 1984 - 1993 (10 years)

UER = (0.38 lb/yd^3) (1.0 ft) (108 miles) (100 ft) (1/10 years) (ton/2000 lb) (yd^3/27 ft^3) (5280 ft/mile)
= 40.1 tons/year for years 1984 - 1993

b) Trenching

EF = 0.037 lb/ton (EPA VIII)

Depth of trench = 5 feet
Length of trench = 108 miles = 570,240 feet
Width of trench = 6 feet
Volume of trench = (5 ft) (570,240 ft) (6 ft)
= 17,107,200 ft^3
= 633,600 yd^3

Assume 1 yd^3 = 1.3 tons

UER = (0.037 lb/ton) (1.3 tons/yd^3) (633,600 yd^3) (1/10 year) (ton/2000 lb)
= 1.5 tons/year
for years 1984 - 1993

c) Backfilling

EF = 0.04 lb/ton (EPA VIII)

UER = (0.04 lb/ton) (1.3 tons/ yd^3) (633,600 yd^3) (1/10 year) (ton/2000 lb)
= 1.6 tons/year
for years 1984 - 1993

d) Wind erosion from disturbed areas

EF = AIKCLV tons/acre-year (WDEQ)

A = Portion of losses which remain suspended = 0.025
I = Soil erodibility = 38 tons/acre-year
K = Surface roughness factor = 1 (Conservative)
C = Climatic factor = 0.345 u^3/PE^2
L = Field width factor = 1 (Conservative)
V = Vegetative cover = 1 (Conservative)
U = Mean wind speed = 13 mph
PE = Thornthwaite's Precipitation - Evaporation Index = 33

$$EF = \frac{(.025)\ (38)\ (0.345)\ (13)^3}{(33)^2} = 0.66 \text{ tons/acre-year}$$

Length of disturbed area = 108 miles/10 years
= 10.8 miles/year
Width of disturbed area = 100 feet

UER = (0.66 tons/acre-year) (10.8 miles) (100 ft) (5280 ft/mile) (acre/43560 ft)
= 86.4 tons/year
for years 1984 - 1993

4. Well Site Preparation

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet

Total acreage disturbed = 503 acres

Years of construction = 1984 - 1993

UER = (0.38 lb/yd^3) (1.0 ft) (503 acres) (43560 ft^2/acre)
(yd^3/27 ft^3) (ton/2000 lb) (1/10 years)
= 15.4 tons/year
for years 1984 - 1993

b) Wind erosion from disturbed areas

EF = 0.66 tons/acre-year (see Calculation 3d)

UER = (0.66 tons/acre-year) (503 acres/10 years)
= 33.2 tons/year
for years 1984 - 1993

c) Excavation of reserve pit

EF = 0.037 lb/ton (EPA VIII)

Assume yd^3 = 1.3 tons

Dimensions = 250 ft X 150 ft X 10 ft = 375,000 feet^3
= 13,899 yard^3

One pit each for 75 wells

UER = (0.037 lb/ton) (1.3 ton/yd^3) (13,889 yd^3) (75/10 years)
(ton/2000 lb)
= 2.5 tons/year
for years 1984 - 1993

5. Electrical Power Distribution System

Same right-of-way as gas gathering system minimal acreage disturbed

6. Sulfur Pipeline

Pipeline is constructed jointly with American Quasar. See American Quasar for emissions calculations. In emissions table, half of the emissions are allocated to Exxon and half to American Quasar.

7. Product Sales Pipeline

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet
93 miles of CO_2 pipeline

93 miles of natural gas pipeline (same ROW)

ROW width = 100 feet

Construction years = 1984 - 1986
(Assumed to be same years as sulfur pipeline construction)

UER = (0.38 lb/yd^3) (93 miles) (100 ft) (1.0 ft) (5280 ft/mile) ($yd^3/27\ ft^3$) (1/3 years) (ton/2000 lbs)
= 115.2 tons/year
for years 1984 - 1986

b) Trenching

EF = 0.037 lb/ton (EPA VIII)

Depth = 5 feet (Assumed same as gas gathering pipeline)
Length = 93 miles = 491,040 feet
Width = 6 feet (Assumed same as gas gathering pipeline)
Volume = 14,731,200 $feet^3$

UER = (0.037 lb/ton) (14,731,200 ft^3) ($yd^3/27\ ft^3$) (1.3 ton/yd^3) (ton/2000 lb) (1/3 years)
= 4.4 tons/year
for years 1984 - 1986

c) Backfilling

EF = 0.04 lb/ton (EPA VIII)

UER = (0.04 lb/ton) (14,731,200 ft^3) ($yd^3/27\ ft^3$) (1.3 ton/yd^3) (ton/2000 lb) (1/3 years)
= 4.7 tons/year
for years 1984 - 1986

d) Wind erosion from disturbed areas

EF = 0.66 tons/acre year (see Calculation 3d)

UER = (0.66 tons/acre year) (491,040 ft) (100 ft) (acre/43560 ft^2) (1/3 years)
= 248 tons/year
for years 1984 -1986

8. Sulfur Loadout Facility

a) Clearing and topsoil removal

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet

UER = (0.38 lb/yd^3) (yd^3/27 ft^3) (1.0 ft) (240 acres)
(43560 ft^2/acre) (ton/2000 lb) (1/3 years)
= 24.5 tons/year
for years 1984 - 1986

b) Wind erosion from disturbed area

EF = 0.66 tons/acre-year (see Calculation 3d)

UER = (0.66 tons/acre-Year) (240 acres/3)
= 52.8 tons/year
for years 1984 - 1986

9. Well Field Construction Employee Traffic on Unpaved Roads

$$EF = (0.6)\ (0.81s)\ (S/30)^n\ \ (d/365)\ (N/4)\ \text{lb/VMT (WDEQ)}$$

s = silt content of road, % = 12
S = vehicle speed, mph = 20
d = dry days/year = 265
N = number of wheels = 4

$$n = \left\{ \begin{array}{l} 1 \text{ if } S \geq 30 \\ 2 \text{ if } S < 30 \end{array} \right. = 2$$

Assume watering of unpaved roads for 50% dust control

$$EF = (0.6)\ (0.81)\ (12)\ (20/30)^2\ (265/365)\ (4/4) = 1.9 \text{ lb/VMT}$$

Assume each employee drives 10 miles per day 5 days per week during April - October

VMT/year = (no. of employees) (10 vehicle miles/employee-day)
(5 days/week) (4 weeks/month) (7 months/year)
= (no. of employees) (1400 VMT/employee)

UER = (VMT/year) (1.9 lb/VMT) (ton/2000 lb)

CER = UER (1-.50)

Year	No. of Employees[1]	VMT/Year	UER (tons/year)	CER (tons/year)
1984	83	116,200	110	55
1985	626	876,400	833	416
1986	488	683,200	649	325
1986	140	196,000	186	93
1988	146	204,400	194	97
1989	286	400,400	380	190
1990	163	228,200	217	108
1991	173	242,200	230	115
1992	180	252,000	239	120
1993	180	252,000	239	120

[1] Based on employment projections for pipeline construction employees plus well field employees developed by Western Research Corporation 9-27-82.

10. Plant Construction Employee Traffic on Unpaved Roads

EF = 1.9 Lb/VMT (see Well Field Construction Employee Traffic)

Access road to West Dry Basin is paved (no emissions)
Access road to Big Mesa = 5 miles unpaved

VMT/Year = (No. employees) (5 miles/trip) (2 trips/employee-day)
(5 days/week) (52 weeks/year)
= (No. employees) (2600)

UER = (VMT/Year) (1.9 Lb/VMT) (Ton/2000 Lb)

Assume watering for 50% dust control

CER = UER (1-0.50)

Year	No. of Employees[1]	VMT/Year	UER (tons/year)	CER (tons/year)
1989	450	1,170,000	1,112	556
1990	406	1,055,600	1,003	501
1991	344	894,400	850	425
1992	150	390,000	371	185
1993	91	236,600	225	112

[1] Based on employment projections provided by Wyoming Research Corporation 9-27-82 for plant construction employees.

11. Plant Construction Employee Traffic for Shute Creek Alternative

Unpaved access road to Shute Creek is approximately 12 miles long

EF = 1.9 Lb/VMT (see well field construction employee traffic)

VMT/year = (No. employees) (12 miles/trip) (2 trips/employee-day) (5 days/week) (52 weeks/year)
= (No. employees) (6240)

UER = VMT/Year) (1.9 Lb/VMT) (Ton/2000 Lb)

Assume watering for 50% dust control

CER = UER (1-0.50)

Assume number of employees is the same as for the proposed action

Year	No. of Employees	VMT/Year	UER (tons/year)	CER (tons/year)
1984	281	1,753,440	1,666	833
1985	535	3,338,400	3,171	1,586
1986	380	2,371,200	2,253	1,126
1987	369	2,302,560	2,187	1,094
1988	406	2,533,440	2,407	1,203
1989	450	2,808,000	2,668	1,334
1990	406	2,533,440	2,407	1,203
1991	344	2,146,560	2,039	1,020
1992	150	936,000	889	445
1993	91	567,840	539	270

AMERICAN QUASAR FUGITIVE DUST ESTIMATES

1. Gas Sweetening Plant Construction

EF = 1.2 tons/acre month (AP-42)

Correct the emissions factor for the number of rainy days/year (estimated at 100 days - from map in AP-42)

EF = (1.2 tons/acre month) (265 dry days/365 days)

EF = 0.87 tons/acre month

Acreage/module = 37 acres

Site preparation takes 4 months of earthwork for each module

UER = (0.87 tons/acre month) (37 acres/module) (4 months/year)
= 129 tons/module year

Assume watering for 50% emission control

Year	Modules Under Construction	UER (tons/year)	CER (tons/year)
1985	2	258	129
1986	1	129	65
1987	2	258	129
1988	1	129	65

2. Access Road Construction

EF = 32 lb/grader hour (Wyoming DEQ)

92.2 miles of road will be new or improved

Assume these will be built during years 1982 - 1989

Assume average grader speed of 5 miles/hour and that 4 graders work at one time

UER = (32 lb/grader - hour) (hour/5 miles) (4 graders)
(92.2 miles/8 years) (ton/2000 lb)
= 0.15 tons/year
for years 1982 - 1989

3. Gas Gathering and Trunkline System (pipe laying)

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth of 1.0 feet

Acreage disturbed = 436 (gathering) + 67 (trunk) acres

Assume construction during years 1984 - 1989

UER = (0.38 lb/yd^3) (yd^3/27 ft^3) (1.0 ft) (503 acres)
(43560 ft^2/acre) (ton/2000 lb) (1/6 years)
= 25.7 tons/year
for years 1984 - 1989

b) Trenching

EF = 0.037 lb/ton (EPA VIII)

Depth: 64 inches = 5.3 feet
Length: 72 miles (gathering) + 11 miles (trunk) = 83 miles
Width: 40 inches = 3.3 feet

Assume 1 yd^3 = 1.3 tons

UER = (0.037 lb/ton) (1.3 tons/27 ft^3) (5.3 ft) (3.3 ft) (83 miles)
(5280 ft/mile) (ton/2000 lb) (1/6 years)
= 1.1 tons/year
for years 1984 - 1989

c) Backfilling

EF = 0.04 lb/ton (EPA VIII)

UER = (0.04 lb/ton) (1.3 tons/27 ft^3) (5.3 ft) (3.3 ft) (83 miles)
(5280 ft/mile) (ton/2000 lb) (1/6 years)
= 1.2 tons/year
for years 1984 - 1989

d) Wind erosion from disturbed areas

EF = AIKCLV tons/acre - year (WDEQ)

A = Portion of losses which remain suspended = 0.025
I = Soil erodibility = 38 tons/acre - year
K = Surface roughness factor = 1 (Conservative)
C = Climatic factor = 1 (Conservative)
L = Field width factor = 1
V = Vegetative cover = 1
U = Mean wing speed = 13 mph
PE = Thornthwaite's Precipitation - Evaporation Index = 33

$$EF = \frac{((.025)\ (38)\ (.345)\ (13)^3}{(33)^2} = 0.66 \text{ tons/acre - year}$$

UER = (0.66 tons/acre - year) (503 acres/6 years)
= 55.3 tons/year

4. Well Site Preparation

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet

72 wells of 3.7 acres each = 266.4 acres

Well sites developed 1982 - 1989 (8 years)

UER = (0.38 lb/yd^3) (yd^3/27 ft^3) (1.0 ft) (266.4 acres/8 years)
(43560 ft^2/acre) (ton/2000 lb)
= 10.2 tons/year
for years 1982 - 1989

b) Wind erosion from disturbed areas

EF = 0.66 tons/acre year (see Calculation 3d)

UER = (0.66 tons/acre year) (266.4 acres/8)
= 22.0 tons/year

c) Excavation of reserve mud pit

EF = 0.037 lb/ton (EPA VIII)

Assume 1.3 tons = 1 yd^3

Volume = 200 ft X 140 ft X 10 ft = 280,000 ft^3 for each

UER = (0.037 lb/ton) (1.3 tons/yd^3) (yd^3/27 ft^3) (280,000 ft^3/well)
(72 wells/8 years) (ton/2000 lb)
= 2.2 tons/year
for years 1982 - 1989

5. Power Cable Burial

Any necessary power cables would be buried coincident with the gas gathering lines, so there would be minimal additional disturbance

6. Sales Pipeline

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet
Length of sales pipeline = 84 miles
Width of ROW = 50 feet

UER = (0.38 lb/yd^3) (yd^3/27 ft^3) (1.0 ft) (50 ft) (84 miles)
(5280 ft/mile) (ton/2000 lb) (1/3 years) = 52 tons/year
for years 1984 - 1986 (Assumed)

b) Trenching

EF = 0.037 lb/ton (EPA VIII)

Dimensions = 84 miles X 40 inches X 64 inches

UER = (0.037 lb/ton) (1.3 ton/27 ft^3) (84 miles) (5280 ft/mile)
(40 in) (64 in) (ft^2/144 in^2) ton/2000 lb) (1/3 years)
= 2.3 tons/year
for years 1984 - 1986

c) Backfilling

EF = 0.04 lb/ton

UER = (0.04 lb/ton) (1.3 ton/27 ft^3) (84 miles/3 years)
(5280 ft/mile) (40 in) (64 in) (ft^2/144 in^2) (ton/2000 lb)
= 2.5 tons/year
for years 1984 - 1986

d) Wind erosion from disturbed areas

EF = 0.66 tons/acre - year (see Calculation 3d)

UER = (0.66 tons/acre - year) (84 miles/3 years)
(50 ft) (5280 ft/mile) (acre/43560 ft^2)
= 112 tons/year
for years 1984 - 1986

7. Sulfur Pipeline

Pipeline is constructed jointly with Exxon. In the summary table half the emissions are allocated to Exxon and half to American Quasar.

a) Clearing and topsoil removal

EF = .38 lb/yd^3 (EPA VIII)

Surface disturbance = 393 acres
Assume construction during 1984 - 1986
Assume Depth of 1.0 feet

UER = (0.38 lb/yd^3) (yd^3/27 ft^3) (393 acres) (43560 ft^2/acre)
(1.0 ft) (1/3 years) (ton/2000 lb)
= 40.2 tons/year
for years 1984 - 1986

b) Wind erosion form disturbed areas

EF = 0.66 tons/acre year (see Calculation 3d)

UER = (0.66 tons/acre year) (393 acres/3 years)
= 86.5 tons/year

8. Well Field Construction Employee Traffic on Unpaved Roads

$EF = (0.6)\ (0.81)\ (S/30)^{n}\ (d/365)\ (N/4)$ lb/VMT (WDEQ)

s = silt content of road, 5 = 12
S = vehicle speed, mph = 20
d = dry days/year = 265
N = number of wheels = 4

$$n = \begin{cases} 1 \text{ if } S \geq 30 \\ 2 \text{ if } S < 30 \end{cases} = 2$$

Assume watering of unpaved roads for 50% dust control

$EF = (0.6)\ (0.81)\ (12)\ (20/30)^{2}\ (265/365)\ (4/4) = 1.9$ lb/VMT

Assume each employee drives 10 miles per day 5 days per week during April - October

VMT/year = (no. of employees) (10 vehicle miles/employee-day)
(5 days/week) (4 weeks/month) (7 months/year)
= (no. of employees) (1400 VMT/employees)

UER = (VMT/year) (1.9 lb/VMT) (ton/2000 lb)

CER = UER (1-.50)

Year	No. of Employees[1]	VMT/Year	UER (tons/year)	CER (tons/year)
1984	94	131,600	125	63
1985	225	315,000	299	150
1986	246	244,400	327	164
1987-1989	248	347,200	330	165

[1] Based on projected well field employees as determined by Western Research Corporation 9-27-82

9. Plant Construction Employee Traffic for the Buckhorn Alternative

EF = 1.9 Lb/VMR (see Well Field Construction Traffic)

Length of unpaved access road is assumed to be 13 miles

VMT/Year = (No. of employees) (13 miles/trip) (2 trips/employee-day)
(5 days/week) (52 weeks/year)
= (No. employees) (6760)

UER = (VMT/Year) (1.9 Lb/VMT) (Ton/2000 Lb)

Assume watering for 50% dust control

CER = UER (1-0.50)

Assume number of employees is the same as for the proposed action

Year	No. of Employees	VMT/Year	UER (tons/year)	CER (tons/year)
1984	339	2,291,640	2,177	1,089
1985	862	5,827,120	5,536	2,768
1986-1989	262	1,771,120	1,683	841
1990	65	439,400	417	209

NORTHWEST PIPELINE AND MOBIL OIL CORPORATION

FUGITIVE DUST ESTIMATES

1. Gas Sweetening Plant Construction

EF = 1.2 tons/acre month (AP-42)

Correct the emissions factor for the number of rainy days/year (estimated at 100 days - from map in AP-42)

EF = (1.2 tons/acre month) (265 dry days/365 days)

EF = 0.87 tons/acre month

Site grading required for 160 acres at Craven Creek and takes place during 8 months of 1984

UER = (0.87 tons/acre month) (160 acres) (8 months/year)
= 1,114 tons/year

Assume watering for dust control of 50%

CER (1984) = (1,114 tons/year) (1-.50)
= 557 tons/year

2. Access Road Construction (Well Drilling)

EF = 32 lb/grader hour (Wyoming DEQ)

8 - 10 miles of new roads (assume 10)

Construction period: 1982 - 2009 (27 years)

Assume 4 graders run at 5 mph

UER = (32 lb/grader hour) (4 graders) (hour/5 miles) (10 miles/27 years) (ton/2000 lb)
= .005 tons/year
for years 1982 - 2009

3. Gas Gathering System and Trunkline (pipe laying)

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet = 0.33 yards

System	Length	Width	Area	Volume
Gathering	75 miles	50 feet	2,200,000 yd^2	733,333 yd^3
Trunk	43 miles	75 feet	1,892,000 yd^2	630,667 yd^3

UER = (0.38 lb/yd^3) (1,364,000 yd^3) (1/4 years) (ton/2000 lb)
= 64.8 tons/year
for years 1984 - 1987

b) Trenching

EF = 0.037 lb/ton (EPA VIII)

Depth of trench = 5 feet
Length of trench = 75 + 43 miles = 118 miles
Width of trench = 6 feet
Volume of trench = (6 ft) (5 ft) (118 miles) (5280 ft/mile) (yd^3/27 ft^3)
= 692,267 yd^3

UER = (0.037 lb/ton) (1.3 ton/yd^3) (692,267 yd^3/4 years) (ton/2000 lb)
= 4.2 tons/year
for years 1984 - 1987

c) Backfilling

EF = 0.04 lb/ton (EPA VIII)

UER = (0.04 lb/ton) (1.3 ton/yd^3) (692,267 yd^3/4 years) (ton/2000 lb)
= 4.5 tons/year
for years 1984 - 1987

d) Wind erosion from disturbed areas

EF = AIKCLV tons/acre-year (WDEQ)

A = Portion of losses which remain suspended = 0.025
I = Soil erodibility = 38 tons/acre-year
K = Surface roughness factor = 1
C = Climatic factor = 1
L = Field width factor = 1
V = Vegetative cover = 1
U = Mean wind speed = 13 mph
PE = Thornthwaite's Precipitation - Evaporation Index = 33

$$EF = \frac{(.025)\ (38)\ (.345)\ (13)^3}{(33)^2} = 0.66 \text{ tons/acre-year}$$

UER = (0.66 tons/acre-year) [(75 mi) (50 ft) + (43 mi) (75 ft)] (5280 ft/mile) (acre/43560 ft) (1/4 years)
= 139.5 tons/year
for years 1984 - 1987

4. Well Site Preparation

a) Clearing and topsoil stripping

EF = 0.38 lb/yd^3 (EPA VIII)

Assume depth = 1.0 feet

Acreage cleared = 3.7 acres/well site

2 wells drilled years 1982 - 1992, 2000 - 2009 (20 years)
3 wells drilled years 1993 - 1999 (7 years)

UER = (0.38 lb/yd^3) (1.0 ft) (3.7 acres/well) (2 wells/year)
(43560 ft^2/acre) (yd^3/27 ft^3) (ton/2000 lb)
= 2.3 tons/year
for years 1982 - 1992, 2000 - 2009

UER = 2.3 (3/2)
= 3.5 tons/year
for years 1993 - 1999

b) Wind erosion from disturbed areas

EF = 0.66 tons/acre year (see Calculation 3d)

UER = (0.66 tons/acre-year) (3.7 acres/well) (2 wells/year)
= 4.9 tons/year
for years 1982 - 1992, 2000 - 2009

UER = 4.9 (3/2)
= 7.3 tons/year
for years 1993 - 1999

c) Excavation of sump pit

EF = 0.037 lb/ton (EPA VIII)

Assume yd^3 = 1.3 tons

Dimensions = 200' X 140' X 10' = 280,000 feet^3
= 10,370 yard^3

UER = (0.037 lb/ton) (1.3 tons/yd^3) (10,370 yd^3/well)
(ton/2000 lb) (2 wells/year)
= 0.50 tons/year
for years 1982 - 1992, 2000 - 2009

UER = 0.50 (3/2)
= 0.75 tons/year
for years 1993 - 1999

5. Rail Spur Earthwork

a) Grading

EF = 0.38 lb/yd^3 (EPA VIII)

Depth = 1.5 feet (Assumed)
Width = 50 feet
Length = 7.6 miles = 40,128 feet
Volume = (50 ft) (40,128 ft) (1.5 ft) = 3,009,600 feet^3
= 111,467 yard^3

UER = (0.38 lb/yd^3) (111,467 yd^3) (ton/2000 lb)
= 21.2 tons/year
for year 1985

b) Cut and fill

EF = 0.037 lb/ton (EPA VIII)

Assume 1.3 ton = yd^3

Depth = 2 feet (Assumed)
Length = 7.6 miles = 40,128 feet
Width = 50 feet
Volume = (40,128 ft) (2 ft) (50 ft) = 4,012,800 feet^3
= 148,622 yd^3

UER = (0.037 lb/ton) (1.3 ton/yd^3) (148,622 yd^3) (ton/2000 lb)
= 3.6 tons/year
for year 1985

6. Transmission Line Construction

a) Excavation for footings

EF = 0.037 lb/ton (EPA VIII)

Assume 1.3 ton per yd^3

Dimensions for each footing: 10 feet deep X 3 feet diameter
Π (1.5 ft)^2 (10 ft) = 71 feet^3

Number of towers between span of 1000 feet
= (25 miles) (5280 ft/mile) (tower/1000 ft)
= 132 towers

Assume 4 footings per tower:
(71 ft^3/footing) (4 footings/tower)
= 284 feet^3/tower

UER = (0.037 lb/ton) (1.3 ton/27 ft^3) (284 ft^3/tower)
(132 towers) (ton/2000 lb)
= 0.033 tons/year
for year 1985

b) Backfilling

EF = 0.04 lb/ton (EPA VIII)

UER = (0.04 lb/ton) (1.3 ton/27 ft^3) (284 ft^3/tower)
(132 towers) (ton/2000 lb)
= 0.036 tons/year
for year 1985

7. Well Field Construction Employee Traffic on Unpaved Roads

EF = (0.6) (0.81s) $(S/30)^n$ (d/365) (N/4) lb/VMT (Wyoming DEQ)
s = silt content of road, % = 12
S = vehicle speed, mph = 20
d = dry days/year = 265
N = number of wheels = 4

$$n = \begin{cases} 1 \text{ if } S \geq 30 \\ 2 \text{ if } S < 30 \end{cases} = 2$$

EF = (0.6) (0.81) (12) $(20/30)^2$ (265/365) (4/4) = 1.9 lb/VMT

Assume each employee drives 10 miles per day 5 days per week during April - October

VMT/year = (no. of employees) (10 vehicle miles/employee-day)
(5 days/week) (4 weeks/month) (7 months/year)
= (no. of employees) (1400 VMT/employee)

UER = (VMT/year) (1.9 lb/VMT) (ton/2000 lb)

Assume dust control of 50% for watering

CER = UER (1-0.50)

Year	No. of Employees[1]	VMT/Year	UER (tons/year)	CER (tons/year)
1984	59	82,600	78	39
1985	59	82,600	78	39
1986	155	217,000	206	103
1987	60	84,000	80	40

[1] Based on Western Research Corporation employment projections (9-27-82) for Mobil well field employees plus NWP gathering system construction employees.

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(June 1984)

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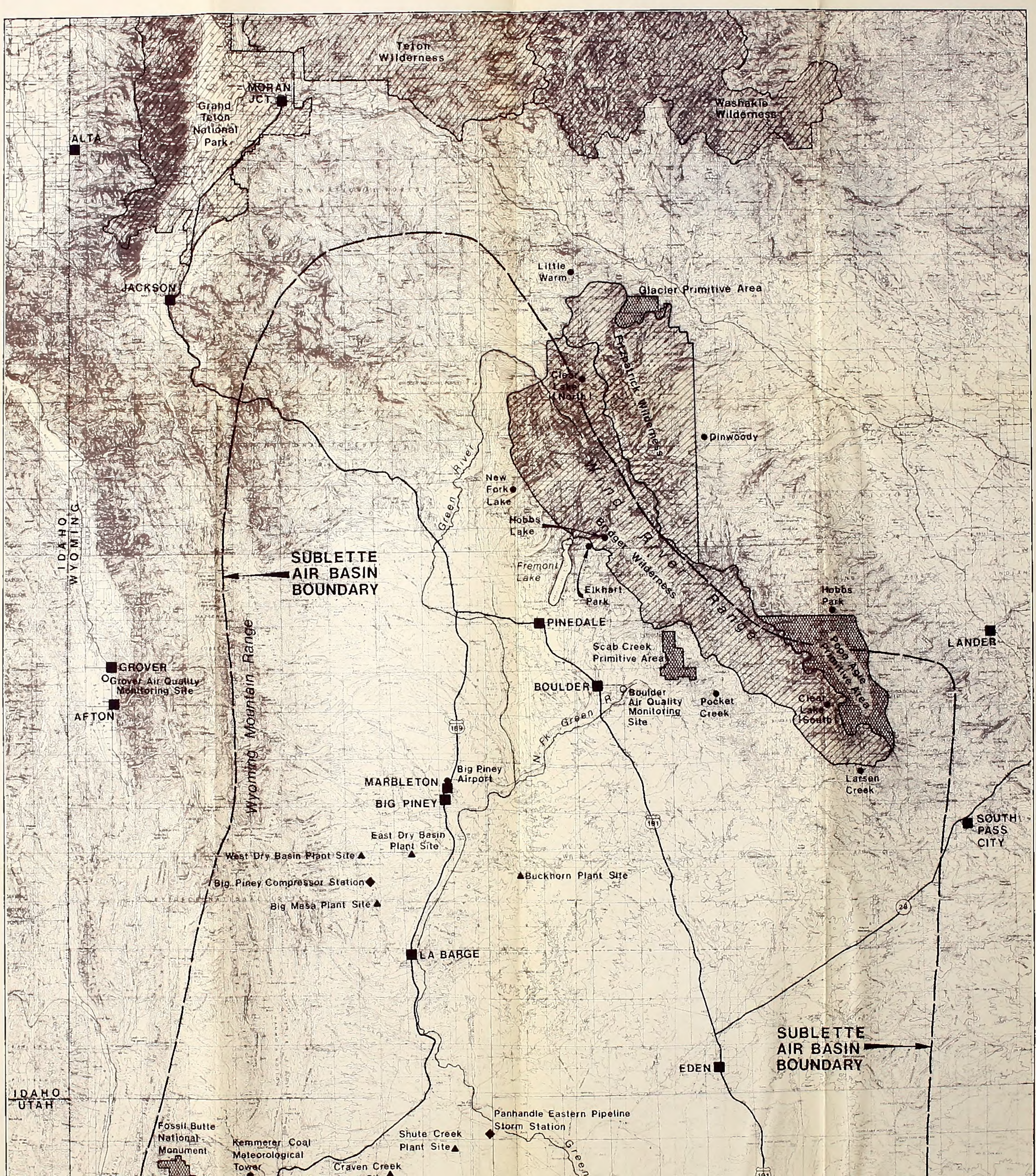
Teton Wilderness
MORAN JCT.
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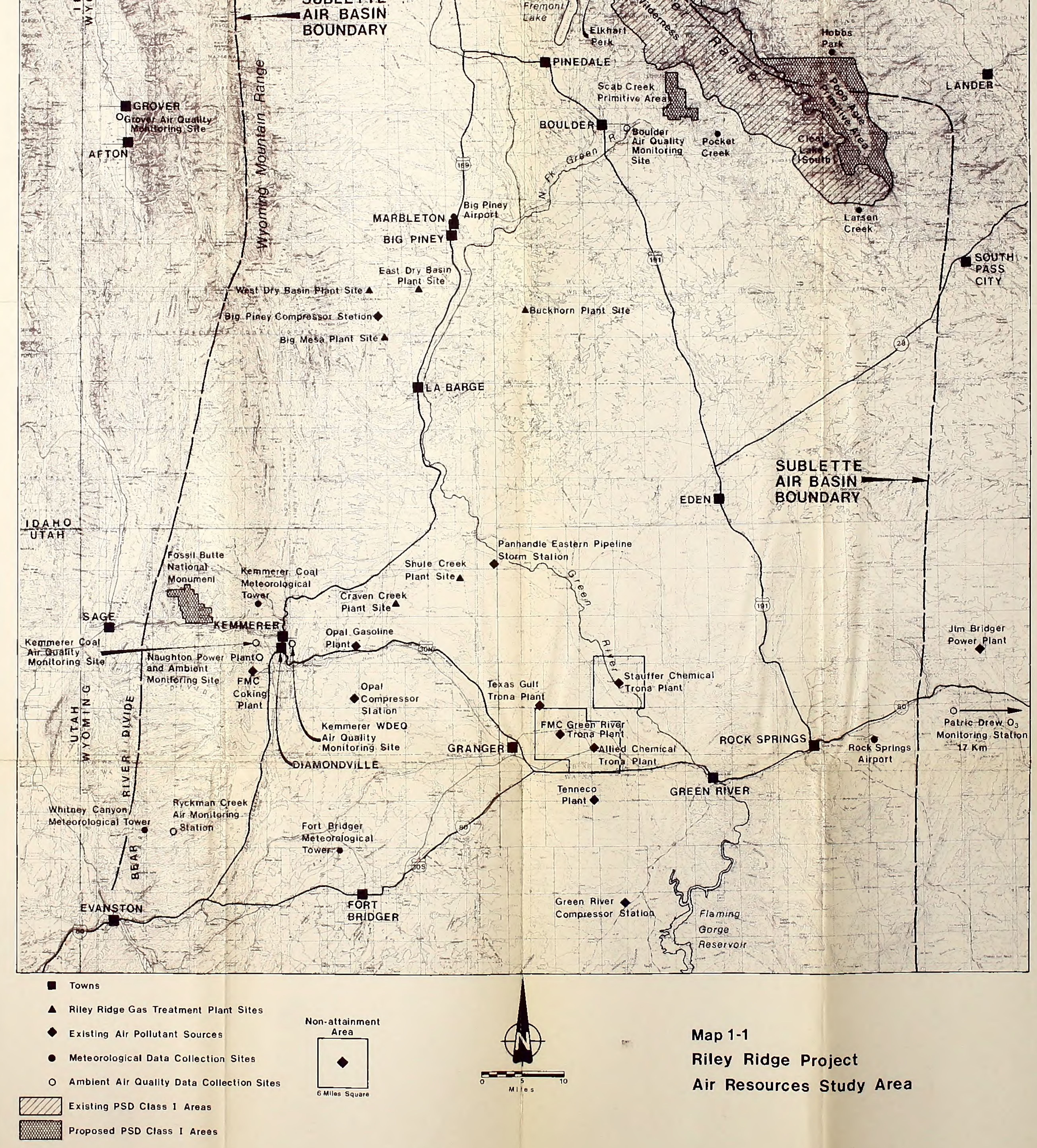
ALTA
Little Warm
Glacier Primitive Area
JACKSON
Fitzpatrick Wilderness
Clear Lake (North)
Dinwoody
Green River
New Fork Lake
Hobbs Lake
Bridger Wilderness
Wind River Range
IDAHO
WYOMING
SUBLETTE AIR BASIN BOUNDARY
Fremont Lake
Elkhart Park
Hobbs Park
PINEDALE
Scab Creek Primitive Area
Popo Agie Primitive Area
LANDER
GROVER
Grover Air Quality Monitoring Site
AFTON
BOULDER
Boulder Air Quality Monitoring Site
Pocket Creek
Clear Lake (South)
Wyoming Mountain Range
N. Fk. Green R.
189
Big Piney Airport
MARBLETON
BIG PINEY
Larsen Creek
191
SOUTH PASS CITY
East Dry Basin Plant Site
West Dry Basin Plant Site
Big Piney Compressor Station
Buckhorn Plant Site
Big Mesa Plant Site
28
LA BARGE
SUBLETTE AIR BASIN BOUNDARY
EDEN
IDAHO
UTAH
Panhandle Eastern Pipeline Storm Station
Fossil Butte National Monument
Kemmerer Coal Meteorological Tower
Shute Creek Plant Site
Craven Creek
Green


SUBLETTE AIR BASIN BOUNDARY
Fremont Lake
Elkhart Park
Wilderness
Range
Hobbs Park
PINEDALE
LANDER
Scab Creek Primitive Area
Popo Agie Primitive Area
BOULDER
Boulder Air Quality Monitoring Site
Pocket Creek
Clear Lake South
N. Fk. Green R.
GROVER
Grover Air Quality Monitoring Site
AFTON
Wyoming Mountain Range
189
Big Piney Airport
MARBLETON
BIG PINEY
Larsen Creek
191
SOUTH PASS CITY
East Dry Basin Plant Site
West Dry Basin Plant Site
Big Piney Compressor Station
Buckhorn Plant Site
Big Mesa Plant Site
28
LA BARGE
SUBLETTE AIR BASIN BOUNDARY
EDEN
IDAHO
UTAH
Panhandle Eastern Pipeline Storm Station
Fossil Butte National Monument
Kemmerer Coal Meteorological Tower
Shute Creek Plant Site
Green River
Craven Creek Plant Site
191
SAGE
KEMMERER
Kemmerer Coal Air Quality Monitoring Site
Opal Gasoline Plant
30N
Jim Bridger Power Plant
Naughton Power Plant and Ambient Monitoring Site
FMC Coking Plant
Opal Compressor Station
Texas Gulf Trona Plant
Stauffer Chemical Trona Plant
UTAH
WYOMING
BEAR RIVER DIVIDE
Kemmerer WDEQ Air Quality Monitoring Site
FMC Green River Trona Plant
80
Patric Drew O3 Monitoring Station 17 Km
DIAMONDVILLE
GRANGER
Allied Chemical Trona Plant
ROCK SPRINGS
Rock Springs Airport
GREEN RIVER
Tenneco Plant
Whitney Canyon Meteorological Tower
Ryckman Creek Air Monitoring Station
Fort Bridger Meteorological Tower
80
30S
EVANSTON
FORT BRIDGER
Green River Compressor Station
Flaming Gorge Reservoir
80
■ Towns
▲ Riley Ridge Gas Treatment Plant Sites
◆ Existing Air Pollutant Sources
● Meteorological Data Collection Sites
○ Ambient Air Quality Data Collection Sites
▨ Existing PSD Class I Areas
▩ Proposed PSD Class I Areas
Non-attainment Area
6 Miles Square
N
0
5
10
Miles

Map 1-1
Riley Ridge Project
Air Resources Study Area

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